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ABSTRACT

Described are the essential concepts included in the subject model. Analysis of the systems approach to the model is presented along with discussions of its applicability to problem solving and decision making, energy-environmental career decisions, lifestyle assessment, and environmental worldviews. Also included are: (1) discussions of fundamental concepts of energy; (2) energy resource delivery systems; (3) forecasting, planning, and policy formation; and (4) futures theory. A section is devoted to a subject matter and cultural process matrix. A glossary is provided at the end of the document. (RE)

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CONTENT SOURCEBOOK

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THE HIGH SCHOOL ENVIRONMENTAL EDUCATION TEACHER TRAINING MODEL:

AN ENERGY-FOCUSED PERSPECTIVE

FAR WEST LABORATORY FOR EDUCATIONAL RESEARCH AND DEVELOPMENT

SE 028 618

THE ENVIRONMENTAL EDUCATION
TEACHER TRAINING MODEL

THE CONTENT SOURCEBOOK

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PREFACE

Under a contract with the Office of Environmental Education of OE, the Far West Laboratory for Educational Research and Development has developed a set of Environmental Education Teacher Training Models (EETMs). Two of these Models address Environmental Education with a special focus on energy; the aim of the others is the fusion of Environmental Education (EE) concepts with natural science and social studies concepts. The two Models that have a special focus on energy are developed for two distinctively different target groups. The first is intended for high school teachers. The second Model is aimed at community groups identified as leaders in fields of environmental concerns. The components of the Models, their structure, and the approach to their design, however, are quite similar.

Each of the four Models is presented in separate documents and the entire set is accompanied by a resource book for curriculum content, called the Sourcebook. The Models* were designed to orient a variety of users to a systemic environmental education design process, but are primarily applicable for developers of teacher training curricula. The function of the Sourcebook can be best understood in the context of the generic Model, of which the Sourcebook is one component.

The Environmental Education Teacher Training Models address comprehensively the purpose and goals of holistic environmental education, and transform these at the individual Model level into components that represent specifications for the development of four training programs.

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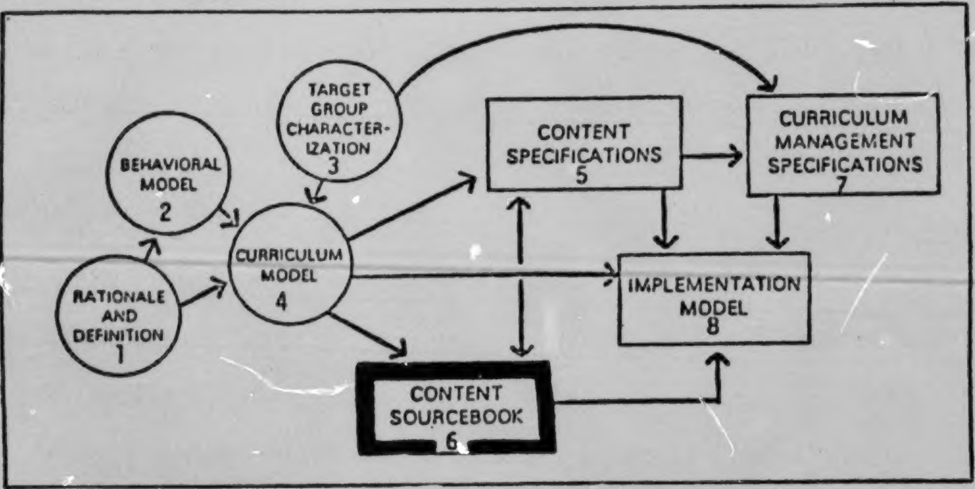
*Figure 1 introduces a generic image of the Models.

The components that comprise the EETM and the manner in which they are developed address eight major practitioner/user-oriented inquiries, which were the basis for the design of the Models. These inquiries are as follows:

Practitioner Questions	Relevant Model Components
• Why this model?	Rational and Definition
• What outcomes are to be attained?	Behavioral Model
• Who are the users?	Target Group Characterization
• How is the curriculum organized?	Curriculum Model
• What do I need to know to attain outcomes?	Content Specifications
• What understanding and knowledge resources do I need to develop the curriculum?	Content Sourcebook
• What instructional/learning arrangements are needed?	Curriculum Management Specifications
• What organizational and logistical arrangements are needed?	Implementation Model


TARGET GROUP CHARACTERIZATION 3
BEHAVIORAL MODEL 2
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CURRICULUM MANAGEMENT SPECIFICATIONS 7
CURRICULUM MODEL 4
RATIONALE AND DEFINITION 1
IMPLEMENTATION MODEL 8
CONTENT SOURCEBOOK 6

Figure 1. A GENERIC IMAGE OF THE ENVIRONMENTAL EDUCATION TEACHER TRAINING MODELS

1. THE RATIONALE FOR AND DEFINITION OF ENVIRONMENTAL EDUCATION and the need for the models.
2. The BEHAVIORAL MODEL characterizes the general knowledge, skill, and attitude requirements that define the literate and competent environmental education teacher. It is derived from the RATIONALE.
3. The TARGET GROUP CHARACTERIZATION defines the target groups and provides a means to assess their current level of competence in order to ensure the compatibility of the Model with their needs.
4. The CURRICULUM MODEL provides an organized description of the various curriculum content domains within which potential teachers need to attain competence. It is consistent with the RATIONALE and represents an elaboration of the BEHAVIORAL MODEL and the TARGET GROUP CHARACTERIZATION.
5. The CONTENT SPECIFICATIONS present the knowledge components for environmental education, and a description of their instructional foci and purposes. These specifications were designed to satisfy requirements of the knowledge component of the CURRICULUM MODEL.
6. The CONTENT SOURCEBOOK presents an elaborated discussion of the knowledge components of the content model, and an annotated resource bibliography and glossary. The requirements for the SOURCEBOOK are defined by the CURRICULUM MODEL and CONTENT SPECIFICATIONS. The SOURCEBOOK is also a main resource for implementation.

7. The CURRICULUM MANAGEMENT SPECIFICATIONS provides general instructional arrangements for teachers to purpose, implement, and evaluate environmental education curricula. This component was derived from and further elaborates the skills component of the CURRICULUM MODEL and CONTENT SPECIFICATIONS.

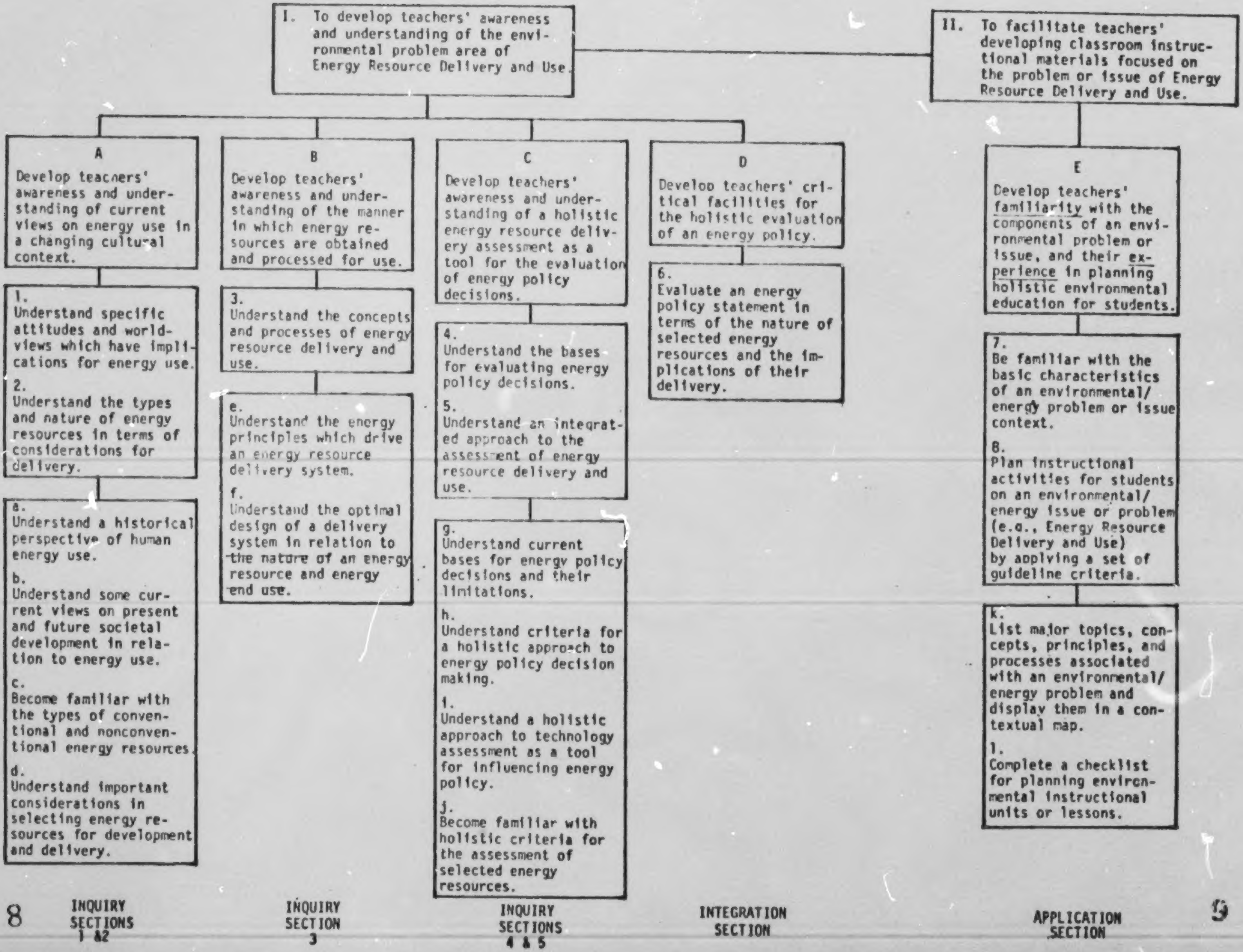
8. The IMPLEMENTATION MODEL presents the conceptual bases and functions of the implementation process, together with characteristic activities associated with each phase of the process. The implementation design was guided by the CURRICULUM MODEL.

The *Sourcebook* is presented in this document as an essential component of the four models and it is seen as an indispensable source in the development of instructional and learning resources.

ACKNOWLEDGEMENTS

Far West Laboratory would like to acknowledge the contribution of the Institute for Advanced Systems Studies, California State Polytechnic University at Pomona for the preliminary development of the Systems Approach section of the *Sourcebook*. We would also like to thank the following Far West Laboratory staff members for their invaluable clerical assistance: Carol Burkhardt, Juliette Van, Katherine Vaz, Marilyn M. White, Rick Grasso, and Mars Marcilan.

MODULE GOALS AND OBJECTIVES



I. To develop teachers' awareness and understanding of the environmental problem area of Energy Resource Delivery and Use.

- A. Develop teachers' awareness and understanding of current views on energy use in a changing cultural context.
  - 1. Understand specific attitudes and worldviews which have implications for energy use.
  - 2. Understand the types and nature of energy resources in terms of considerations for delivery.
    - a. Understand a historical perspective of human energy use.
    - b. Understand some current views on present and future societal development in relation to energy use.
    - c. Become familiar with the types of conventional and nonconventional energy resources.
    - d. Understand important considerations in selecting energy resources for development and delivery.
- B. Develop teachers' awareness and understanding of the manner in which energy resources are obtained and processed for use.
  - 3. Understand the concepts and processes of energy resource delivery and use.
    - e. Understand the energy principles which drive an energy resource delivery system.
    - f. Understand the optimal design of a delivery system in relation to the nature of an energy resource and energy end use.
- C. Develop teachers' awareness and understanding of a holistic energy resource delivery assessment as a tool for the evaluation of energy policy decisions.
  - 4. Understand the bases for evaluating energy policy decisions.
  - 5. Understand an integrated approach to the assessment of energy resource delivery and use.
    - g. Understand current bases for energy policy decisions and their limitations.
    - h. Understand criteria for a holistic approach to energy policy decision making.
    - i. Understand a holistic approach to technology assessment as a tool for influencing energy policy.
    - j. Become familiar with holistic criteria for the assessment of selected energy resources.
- D. Develop teachers' critical facilities for the holistic evaluation of an energy policy.
  - 6. Evaluate an energy policy statement in terms of the nature of selected energy resources and the implications of their delivery.

II. To facilitate teachers' developing classroom instructional materials focused on the problem or issue of Energy Resource Delivery and Use.

- E. Develop teachers' familiarity with the components of an environmental problem or issue, and their experience in planning holistic environmental education for students.
  - 7. Be familiar with the basic characteristics of an environmental/energy problem or issue context.
  - 8. Plan instructional activities for students on an environmental/energy issue or problem (e.g., Energy Resource Delivery and Use) by applying a set of guideline criteria.
    - k. List major topics, concepts, principles, and processes associated with an environmental/energy problem and display them in a contextual map.
    - l. Complete a checklist for planning environmental instructional units or lessons.

INQUIRY SECTIONS 1 &2

INQUIRY SECTION 3

INQUIRY SECTIONS 4 & 5

INTEGRATION SECTION

APPLICATION SECTION

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THE
USER
STRATEGY

The User Strategy addresses the general utility of the Environmental Education Teacher Training Model (EETTM) Sourcebook from the point of view of identifying intended users of the model, describing the curriculum domain of energy-focused environmental education, and enumerating a set of protocol statements as a guide for the programmatic use of the curriculum domain by developers of instructional materials.

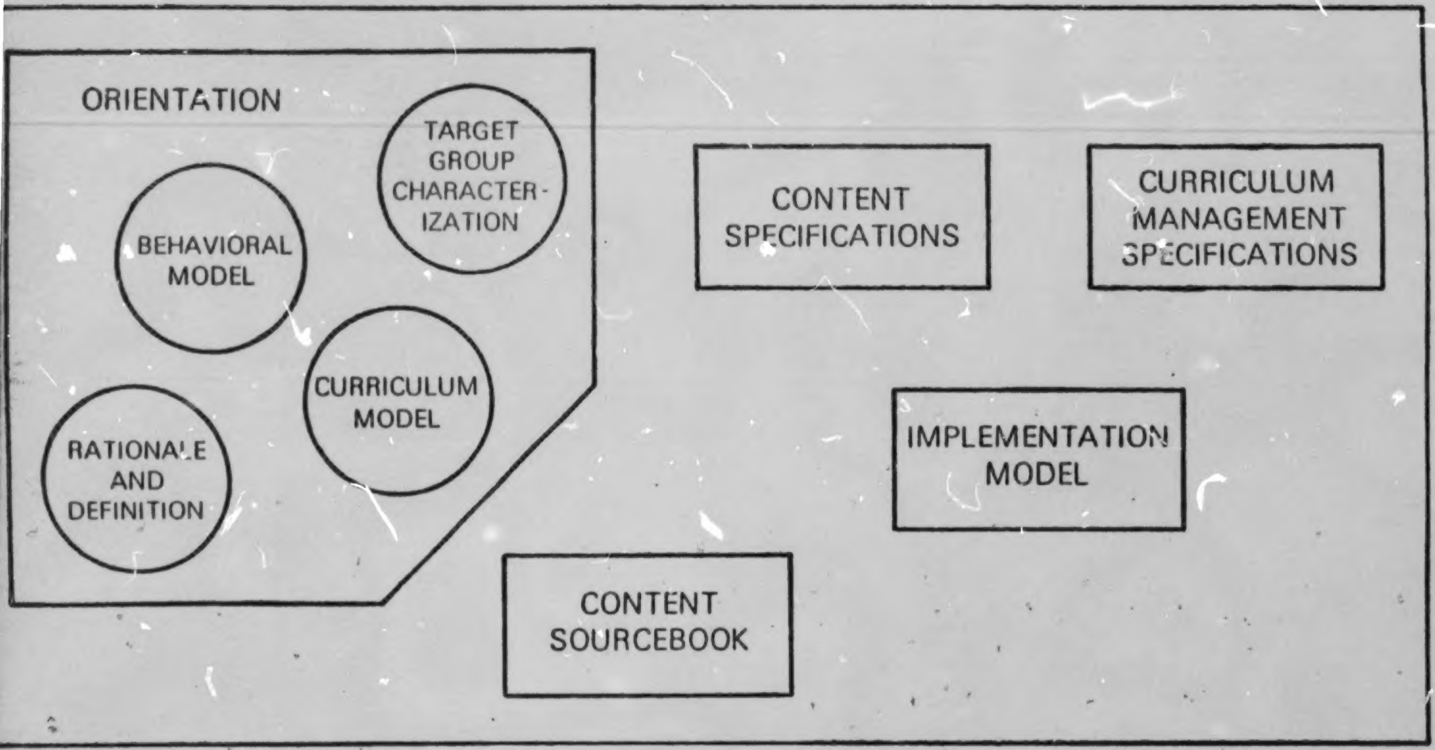
The User Strategy contains:

A. A matrix and discussion of the relationships between the components of the EETTM and intended users.

B. A description and definition of the elements of the curriculum domain of energy/environmental education.

C. A set of protocol statements describing essential relationships among the elements of the EE curriculum domain.

D. A description of the Contextual Map as a framework for developing comprehensive and holistic EE curricula and supporting instructional materials.


ORIENTATION
TARGET GROUP CHARACTERIZATION
BEHAVIORAL MODEL
CURRICULUM MODEL
RATIONALE AND DEFINITION
CONTENT SPECIFICATIONS
CURRICULUM MANAGEMENT SPECIFICATIONS
IMPLEMENTATION MODEL
CONTENT SOURCEBOOK

ENVIRONMENTAL EDUCATION
TEACHER TRAINING MODEL

I. RELATIONSHIPS BETWEEN EETTM COMPONENTS AND INTENDED USERS

THE EETTM DOCUMENTS

The documents comprising the Environmental Education Teacher Training Model are described below.

Orientation	Introduces a systemic approach to the instructional and content domains of holistic energy/environmental education. Contains: Rationale and General Definition of Environmental Education, Behavioral Model, Target Group Characterization and Curriculum Model.
Content Specifications	Describes the components of the environmental education content model (e.g., Energy Delivery Systems, Futures Thinking).
Content Sourcebook	Provides an extensive resource base for developing instructional/learning materials: includes elaborated description of the content components, an annotated bibliography and a glossary.
Curriculum Management Specifications	Describes a general instructional management sequence to purpose, plan, implement and evaluate an energy/environmental education curriculum.
Implementation Model	Describes characteristic activities needed to effect a comprehensive, effective EE teacher training program in a variety of settings.

INTENDED USERS

The documents described on the previous page comprise the components of the Environmental Education Teacher Training Model. They maybe used in a variety of ways, depending on the focus and goal of the intended user. The relationships between EETTM documents and their intended users are presented on the following pages and summarized in Table 1.

1. EDUCATIONAL RESEARCH AND DEVELOPMENT ORGANIZATIONS

Example:	Application:
Far West Laboratory for Educational Research and Development, Educational Development Center, American Institutes for Research, SRI (Stanford Research Institute).	• Use all documents to produce EE training products at the modular, component, or program level.

2. INTERNATIONAL EE ORGANIZATIONS

Example:	Application:
World Education, International Union for the Conservation of Nature and Natural Resources.	Use all documents to assist in: • developing new training products • developing criteria for evaluating existing programs • developing guidelines for future funding efforts

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3. PROFESSIONAL EDUCATION ASSOCIATIONS

Example	Application
National Science Teachers Association, National Council for the Social Studies, Conservation Education Association.	• Use behavioral, curriculum, and content models as basis for assessing current knowledge, skill, and attitudinal competencies of teachers, and for recommending changes in teacher preparation programs. • Use all documents to develop criteria/guidelines for recommending future research and development efforts. • Use Content Specifications and Content Sourcebook to develop series of introductory articles in professional magazines on "what constitutes holistic energy/environmental education," etc.

4. ENERGY/ENVIRONMENTALLY CONCERNED FEDERAL, STATE AND LOCAL GOVERNMENT AGENCIES

Example	Application
Energy Research and Development Administration, California Conservation Corps, Natural Resource Department.	• Use Content Specifications and Content Sourcebook to generate criteria and guidelines for policy/decision-making regarding program and personnel development.

5. STATE ENVIRONMENTAL DIRECTORS AND TRAINING PERSONNEL

Example	Application
Department of Public Instruction.	• Use all documents to develop criteria for assessing existing stage plans and making recommendations for future changes. • Use Content Specifications and Content Sourcebook (descriptions and annotated bibliography) as basis for presentations, structuring conferences, and making recommendations to the legislature regarding curricula changes.

6. UNIVERSITIES

Example	Application
Teacher Education Departments.	• Use behavioral and curriculum model to assess their array of competencies. • Use all documents to develop course(s) to provide opportunity for secondary teachers to become proficient in planning, developing and implementing energy/environmental education courses. • Use Content Specifications and Content Sourcebook to develop criteria and guidelines for assessing comprehensiveness of existing curricula or establishing an interdisciplinary energy/environmental program at the B.S. or M.S. level.

7. CURRICULUM SPECIALISTS/DEVELOPERS AT SCHOOL DISTRICT LEVEL

Application

- Use behavioral and curriculum model to assess current competence level of teachers.

- Use Content Specifications, Content Sourcebook, and Curriculum Management Specifications to develop criteria to assess current programs and to make recommendations for future training.

- Use Implementation Model to develop effective implementation plan.

8. STATE AND FEDERAL LEGISLATIVE STAFF AND COMMITTEES CONCERNED WITH ENERGY, ENERGY/ENVIRONMENTAL EDUCATION

Application

- Use Content Specifications and Content Sourcebook to develop criteria for reviewing legislation.

9. ENERGY/ENVIRONMENTALLY CONCERNED YOUTH GROUPS

Example	Application
Boy Scouts, Girl Scouts, 4-H.	• Use all documents to develop guidelines for assessing current energy/environmental education programs and for developing new ones.

10. PUBLISHING FIRMS

Example	Application
Harcourt Brace Jovanovich, MIT Press, Scott, Foresman and Co.	• Use Content Specifications and Content Sourcebook to develop guidelines for program development.

11. EDUCATIONAL TELEVISION

Example	Application
Instructional Television, Divisions of PBS at national and local level.	• Use *Content Specifications* and *Content Sourcebook* to develop guidelines for program development.

12. ENERGY/ENVIRONMENTALLY CONCERNED COMMUNITY GROUPS

Example	Application
Sierra Club, Farallones Institute, Friends of the Earth, League of Women Voters.	• Use all documents to develop guidelines for assessing current energy/environmental education programs and for developing new ones.

INTENDED USERS AND APPLICATIONS	DOCUMENTS ASSESSING MODEL COMPONENTS								
	Content Sourcebook			Orientation			Content Specifications	Curriculum Management	Implementation
	Subject Matter/ Process Matrix	Content Descriptions	Annotated Bibliography	Rationale[1]	Behavior Model	Curriculum Model			
1. Educational Research and Development Organizations									
• Producing training products	*	*	*		*	*	*	*	*
2. International EE Organizations									
• Developing training products • Developing program evaluation criteria • Developing future funding guidelines	*	*	*		*	*	*	*	*
3. Professional Education Associations									
• Assessing teacher competence					*	*	*		
• Recommending future R&D	*	*	*		*	*	*	*	*
• Developing publications	*	*	*				*		
4. Energy/Environmentally concerned Federal, State and Local Governmental Agencies									
• Generating criteria and guidelines for policy and decision-making	*	*	*				*		
5. State Environmental Directors and Training Personnel									
• Assessing state plans	*	*	*		*	*	*	*	*
• Making legislative recommendations	*	*	*				*		
6. Universities									
• Assessing teacher competence					*	*			
• Developing teacher training programs	*	*	*		*	*	*	*	*
• Assessing existing curricula/programs	*	*	*				*		

---

[1] Rationale in the Orientation Manual is essential for all intended users to address because it orients the reader to the domains of holistic energy/environmental education.

Table 1. POTENTIAL USERS AND APPLICATIONS FOR THE EETTM

INTENDED USERS AND APPLICATIONS	DOCUMENTS ASSESSING MODEL COMPONENTS								
	Content Sourcebook			Orientation			Content Specifications	Curriculum Management	Implementation
	Subject Matter/Process Matrix	Content Descriptions	Annotated Bibliography	Rationale[1]	Behavior Model	Curriculum Model			
7. Curriculum Specialists/Developers at School District Level • Assessing teacher competence • Developing program assessment criteria • Developing program implementation plans	*	*	*		*	*	*	*	*
8. State and Federal Legislative Staff and Committees • Developing legislative review criteria	*	*	*				*		
9. Energy/Environmentally concerned Youth Groups • Assessing projects/programs or developing new ones	*	*	*		*	*	*	*	*
10. Publishing Firms • Assessing or commissioning publications	*	*	*				*	*	
11. Educational Television • Developing guidelines for program development	*	*	*				*		
12. Energy/Environmentally concerned community groups • Assessing projects/programs or developing new ones	*	*	*		*	*	*	*	*

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[1] Rationale in the Orientation Manual is essential for all intended users to address because it orients the reader to the domains of holistic energy/environmental education.

Table 1 (Continued). POTENTIAL USERS AND APPLICATIONS FOR THE EETTM

II. ELEMENTS OF THE EE CURRICULUM DOMAIN

The curriculum domain of energy/environmental education is composed of several components:

- Issues of National Priority
- Key Environmental Entities
- Settings of Environmental Interest
- Context(s) for Environmental Education
- Content Specifications
- EE Curriculum Map

These elements are considered separately in this section and are blended together by the Protocol outlined in Section C.

ISSUES OF NATIONAL PRIORITY

National priority issues are the environmental issues, topics, and concerns of our national, state, and local leaders. These issues have both broad and specific implications for environmental education, which make them very complex and difficult to handle in instructional situations. Resolution of these issues by our society is an ongoing process that involves making and changing policies, regulations, and legislation; and changing our individual lifestyles as we become more environmentally and energetically aware citizens.

Kahn, Brown, and Martel offer a list of candidates for Issues of National Priority.[1] This list is presented on the following pages. Many items have energy/environmental education implications. Areas 2 and 3 address environmental issues exclusively.

1. Intrinsically dangerous technology

   a. Modern means of mass destruction
   *b. Nuclear reactors--fission or fusion
   c. Nuclear explosives, high-speed gas centrifuges, etc.
   d. Research missiles, satellite launchers, commercial aircraft, etc.
   *e. Biological and chemical "progress"
   f. Molecular biology and genetics
   g. "Mind control"
   h. New techniques for insurgency, criminality, terror, or ordinary violence
   i. New techniques for counterinsurgency, or imposition of order
   j. New serendipities and synergisms

---

[1] Herman Kahn; William Brown; Leon Martel, The Next Two Hundred Years ((New Jersey: William Morrow & Co.), 1976.

*Asterick indicates Issues of National Priority that directly relate to the Key Environmental Entities as specified in the amended EE Act.

*2. Gradual worldwide and/or national contamination or degradation of the environment

   a. Radioactive debris from various peaceful nuclear uses
   b. Possible greenhouse or other effects from increased CO_2 in the atmosphere, new ice age because of dust in stratosphere, damage to ozone layer, etc.
   c. Other special dangerous wastes--methyl mercury, PCB, etc.
   d. Waste heat
   e. Other less dangerous but environment-degrading wastes, such as debris and garbage
   f. Noise, ugliness, and other annoying by-products of many modern activities
   g. Excessive urbanization
   h. Excessive overcrowding
   i. Excessive tourism
   j. Insecticides, fertilizers, growth "chemicals," food additives, plastic containers, etc.

**3. Spectacular and/or multinational contamination or degradation of the environment

   a. Nuclear war
   b. Nuclear testing
   c. Bacteriological and checmical war or accident
   d. Artificial moons
   e. Supersonic transportation (shock values)
   f. Weather control
   g. Big "geomorphological" projects
   h. Million-ton tankers (Torrey Canyon was only 111,825 tons) and million-pound planes
   i. Other enterprise or mechanism of "excessive" size.

---

*Asterisk indicates Issues of National Priority that directly relate to the Key Environmental Entities as specified in the amended EE Act.

**Asterisks indicate entire area pertains to energy/environmental education.

4. Dangerous internal political issues

   a. Computerized records
   b. Other computerized surveillance
   c. Other advanced techniques for surveillance
   d. Excessively degradable (or unreliably reassuring) centralized capabilities
   e. Improved knowledge of and techniques for agitprop and other means of creating distrubances
   f. Improved knowledge of, and techniques for, preventing disturbances
   g. Complex or critical governmental issues leading to either "technocracy" or "Caesarism"
   h. Nuclear weapons affecting internal politics
   i. Excessively illusioned attitudes
   j. Other dangerous attitudes

5. Upsetting international consequences

   a. Both new and "traditional" demonstration effects
   *b. Technological obsolescence of "unskilled" labor
   c. New synthetics--e.g., coffee, oil, etc.
   d. Forced modernization
   e. Growing guilt feelings by many in wealthy nations--particularly among the alienated or young
   f. Inexpensive and widely available "realistic" communications and physical travel
   g. Accelerated "brain drains"
   h. Cheap food
   i. Cheap education
   *j. Control and exploitation of the oceans, space, moon

6. Dangerous personal choices

   a. Sex determination
   b. Other genetic engineering
   c. Psychedelic and mood-affecting drugs
   d. Electronic stimulation of pleasure centers
   e. Other methods of sensual satisfaction
   f. Excessive permissiveness and indulgence
   g. Dropping out and other alienation
   h. Excessive narcissism or other self-regard
   i. Super-cosmetology
   j. Lengthy hibernation

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*Asterisk indicates Issues of National Priority that directly relate to the Key Environmental Entities as specified in the amended EE Act.

7. Bizarre issues

   a. Generational changes--e.g., extended longevity
   b. Mechanically dependent humans--e.g., pacemakers
   c. Life and death for an individual--e.g., artificial kidneys, etc.
   d. New forms of humanity--e.g., "live" computers
   e. "Forcible" birth control for "impossible" groups
   f. Other external controls or influence on what should be a personal or even institutionally private choice
   g. Life and death or other control of "outlaw" societies that have not yet committed any traditional crime
   h. The continuation of the nation-state system
   i. Control and limitation of change and innovation
   *j. Radical ecological changes on a planetary scale
   k. Interplanetary contamination

Kahn, Brown and Martel also address eight "uncertain" issues, of which three are of national level environmental concern:

*1. Effects of U.S. superindustrial economy on environment, society, and culture of the U.S. and the world.

*2. Effects of U.S. posindustrial economy on environment, society, and culture of the U.S. and the world.

3. Parallel developments in other countries.

4. Political, institutional, international-security, and arms-control issues.

*5. Possible damage to earth because of complicated, complex, and subtle ecological and environmental effects.

6. Issues relating to quality of life, attitudes, values, morals, and morale for different nations and groups.

7. Images of the future and the likely problems and opportunities created by these images.

8. Degree and effects of bad luck and bad management.

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*Asterisk indicates Issues of National Priority that directly relate to the Key Environmental Entities as specified in the amended EE Act.

Willis Harris addresses issues of national priority in terms of four major dilemmas confronting society.[2] These four dilemmas specifically address energy/environmental education concerns. The following descriptions are form *The Futurist* article; the emphasis is ours.

1. The Growth Dilemma

   The environmental and social costs of continued exponential growth in energy and materials usage, and economic growth in the forms we have known, appear to be unacceptably high. But the costs of stopping that growth also appear to be unacceptably high.

2. The Control Dilemma

   We need to guide technological innovation but we shun centralized control...The powers of technology to change any and all aspects of the physical, social, political, and psychological environment grow even greater. *In reaction, the society is beginning to demand "technology assessment," a euphemism for anticipatory control, to reduce future negative social and environmental impacts of new technologies*.

3. The Distribution Dilemma

   The industrialized nations find it costly to share the earth's resources with less developed nations, but a failure to do so might prove even more costly. The market system does not of itself include consideration for severe inequities in distribution, just as *it does not consider either the welfare of future generations or the present costs to society and the environment*.

4. The Work-Roles Dilemma

   Industrial society is increasingly unable to supply an adequate number of meaningful social roles. *Population pressure, itself, a consequence of the technology-aided prolonging of human lives, alters the timetable, making problems crucial earlier than they might be if the population were smaller*.

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[2] Willis W. Harmon, "The Coming Transformation," *The Futurist*, Part I, (February, 1977), p.6.

According to Harman, the four dilemmas represent tradeoffs that grow steadily more intolerable, or situations that steadily worsen. The first three dilemmas relate closely to the Faustian powers of technology and what might be called a "new scarcity." The new scarcity arises from approaching the finite planetary limits of:

- fossil fuels and strategic minerals
- natural fresh water
- food-productive, arable land
- habitable surface area
- waste-absorptive capacity of the natural environment
- resilience of the planet's life-support ecosystems

These Issues of National Priority represent the reasoning of leading "futures thinkers." On a more practical level, discussions of ten I.N.P.'s are included in this sourcebook, as an example of discussions teachers and teacher/educators could begin to use in instructional situations.

KEY ENVIRONMENTAL ENTITIES

Key environmental entities are concept/topic areas that are key focal points for environmental education. As indicated in the EE Act as amended, these entities are:

1. Population dynamics
2. Pollution
3. Resource allocation and depletion
4. Conservation
5. Transportation
6. Technology
7. Urban and rural planning
8. Environmental Quality
9. Ecological Balance
10. Natural Resource-Related Careers and Vocations
11. Economic and Technological Development
12. Environmental Ethics
13. Energy[3]

From a holistic understanding of these key Environmental Entities an initial definition emerges for holistic environmental education:

> to develop in learners (trainers, specialists, teachers, and students) an understanding of: (1) how the Key EE Entities are integrated with specified environmental contexts; and (2) how this integration (among the various entities) changes over time with respect to changing contexts.

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[3] Added during 1978 re-authorization proceedings for the EE act.

SETTINGS OF ENVIRONMENTAL INTEREST

Settings of Environmental Interest provide a common background or frame-of-reference within which the patterns or sequential relationships between the Key Environmental Entities can emerge. These settings can be specified in different ways:

1. Macro-settings (large or aggregate level)
    a. According to geographical scale
        (1) local
        (2) state
        (3) regional
        (4) national
        (5) global
    b. According to political jurisdiction
        (1) local city or town
        (2) county
        (3) multi-county
        (4) state
        (5) multi-state
        (6) national
        (7) international
    c. According to ecosystem boundaries. Since ecosystems are open systems, boundaries are established to distinguish the inputs of the system from its internal processes (or throughputs). These boundaries can be defined several different ways:
        (1) Boundaries that contain the internal processes/workings of the system.
        (2) Boundaries that establish the territory from which the system receives its inputs.
        (3) Boundaries that establish the territory to which the system sends its outputs.
2. Micro-settings (small or individual level)
    a. home
    b. neighborhood
    c. school
    d. workplace
    e. recreation area

Associated with these different aspects of settings are inherent time properties, which are important to the dynamic relationship between the settings and the key EE entities. For example, the time scales and rhythms associated with the geographical aspects of a particular setting are probably of a very different duration and/or frequency than are those associated with the political jurisdiction aspects of the setting.

To maintain attention and interest, settings must be of importance to the locale and/or student/learner target group. The difficulty for teachers and teacher educators is in designing instructional arrangements in such a way that the selected "setting" is illuminated against a background of holistic and comprehensive EE, thereby enhancing both levels of educational experience--increased resolution of awareness of the local setting and enhanced understanding of the broad implications of EE.

CONTEXTS FOR ENVIRONMENTAL EDUCATION

Contexts for Environmental Education are formed by combining a Setting of Environmental Interest (such as Appalachia) with a Key Environmental Entity, or cluster of entities (such as urban and rural planning) for the purpose of investigating an Issue of National Priority. As the characteristics of the setting change over time (physically, politically, etc.), or new entities are introduced, the context is changed.

CONTENT SPECIFICATIONS

The Content Specifications of the EETTM describe the components of the energy/environmental education curriculum content models. These components represent a conceptualization of the basic set of indicators and processes for gauging or explaining the changing interaction and integration of all EE entities over time within a given energy/environmental context. The components of the four EETTM content models are listed below.

1. Systems Approach
2. Analytical Tools for Understanding Energy/Environment Systems
3. Problem-Solving and Decision-Making
4. Energy/Environment Related Decisions
5. Holistic Lifestyle Assessment
6. Ideal Environmental Worldviews
7. Fundamental Concepts of Energy
8. Net Energy Analysis
9. Energy Quality
10. Resource Delivery Systems
11. Forecasting for Planning and Policy Formation
12. Futures Thinking

These content components emphasize three major characteristics or aspects of any energy/environmental context:

1. Complexity: Any context is a complex system with many parts and processes.
2. Integration: All parts within a content system are interrelated and each part affects and is affected by the other parts.
3. Dynamic nature: The integration (nature and degree of interrelationship, interaction) of the parts within a content system changes over time.

THE CURRICULUM MAP

The Curriculum Map (Figure 2) is a matrix showing the interactions of Energy/Environmental Education SUBJECT MATTER AREAS and the BASIC PROCESSES OF THE CULTURE. The purpose of the Map is to help energy/environmental educators: (1) to identify and select potential EE curriculum content from the perspective of their professional subject matter/processes competence and interests; and (2) to be able to associate EE subject matter and cultural processes with appropriate EE principles and concepts, learning materials and other resources, and learning/competence objectives.

The SUBJECT MATTER AREAS displayed in the curriculum map describe topics or topic areas that are compatible with the basic disciplines of both Natural Science and the Social Sciences. These topic areas are as follows:

1. Cultural Development and Natural Resources
    a. Natural Resource Bases
    b. Human Evolution and Adaptation
    c. Evolution of Cultural Form
    d. Cultural Forms and Changing Resource Bases
    e. Cultural Adaptations and Changing Resource Bases
2. Contemporary Social System Requirements
    a. Human Needs (Individual and Social)
    b. Socially Derived Needs
3. Energy Basis of Humanity and Nature
    a. Physical/Chemical Properties
    b. Biological (Bio-) Energetics
    c. Macro-Energy Systems Behavior

4. Energy and Culture
    a. Energy and Social Dynamics
    b. Energy and Technology
    c. Energy Dynamics and Community Form
    d. Energy and Citizenship (Aggregate)
    e. Energy and Citizenship (Individual)
5. Energy and Well-Being
    a. Energy, Technology, and Health
    b. Energy Utilization

The PROCESSES OF THE CULTURE displayed in the curriculum map matrix consist of the basic cognitive and affective processes that are employed by all learners in investigation and exploration EE contexts. These are as follows:

1. Problem-solving at the levels of:
    a. art
    b. craft
    c. technology
    d. paradigm
2. Decision-making
    a. scientific
    b. management
3. Envaluation
    a. as an individual
    b. between individual and a group or institution
    c. between or among groups or institutions

The instructional considerations that are addressed by the intersections of SUBJECT MATTER and PROCESSES in the curriculum map involve:

1. Concepts, principles, and themes that can address specific EE contexts
2. General competence objectives that satisfy the learning requirements for holistic energy/environmental awareness. These are written at the level of the environmentally aware and/or energy literate citizen.

		PROCESSES OF THE CULTURE			
		Problem-solving	Decision-Making		Envaluation
			Scientific	Management	
SUBJECT MATTER AREAS	Cultural Development & Natural Resources				
	Contemporary Social Systems Requirements				
	Energy Basis of Humanity and Nature				
	Energy and Culture				
	Energy and Well-Being				

Figure 2. THE CURRICULUM MAP

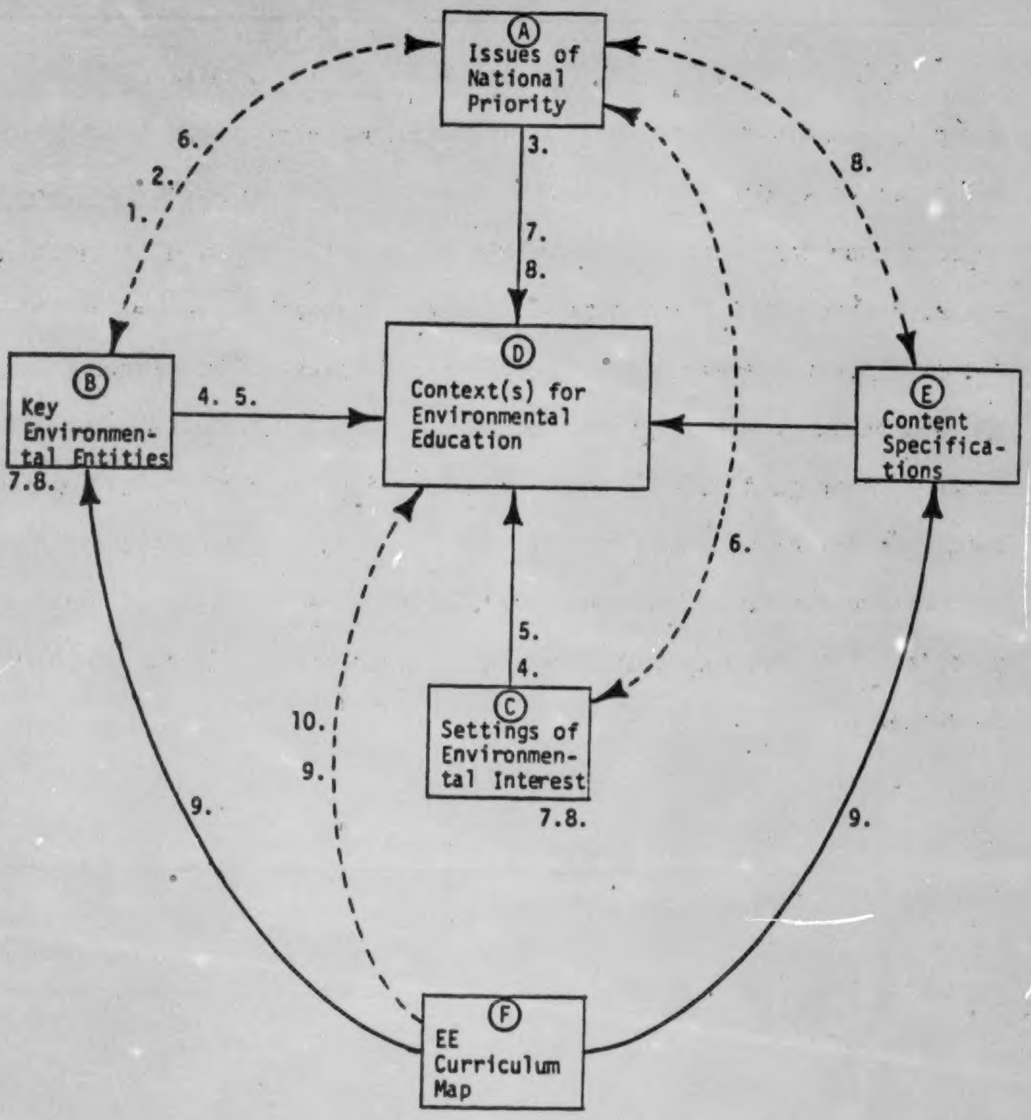
Each SUBJECT MATTER/PROCESS intersection addresses:

- EE principles/concepts
- instructional resources
- learning competences

III. PROTOCOL FOR LINKING THE COMPONENTS OF THE EE CURRICULUM DOMAIN

This protocol defines the essential qualities of the relationships among the components of the EE Curriculum Domain described in Section B, and provides several guidelines for their utilization. The purpose of these components is to facilitate the design of learning experiences and activities that illuminate and explore the topics, concepts, and themes of energy/environmental problems and issues. The protocol is not sequentially prescriptive, but relationally prescriptive--i.e., the purpose is to guide the sequence of developing learning activities so that a holistic and comprehensive overall learning experience is arranged.

Figure 3 illustrates the interlocking characteristics of the components. The importance of a holistic perspective of EE should therefore be evident.



A
Issues of National Priority
B
Key Environmental Entities
C
Settings of Environmental Interest
D
Context(s) for Environmental Education
E
Content Specifications
F
EE Curriculum Map
6.
2.
1.
3.
7.
8.
8.
4. 5.
7.8.
6.
5.
4.
10.
9.
9.
7.8.
9.

Figure 3. RELATIONSHIPS AMONG THE COMPONENTS OF THE EE CURRICULUM DOMAIN

NOTE: Numbers refer to Protocol statements (Section III).
Letters refer to definitions of the components (Section II).
(——) = Primary interaction
(----) = Secondary interaction

PROTOCOL STATEMENTS

1. For the purposes of environmental education (as defined by the Act as amended), any given Issue of National Priority (A) should be studied in terms of the Key Environmental Entities (B).

2. Holistic environmental education addresses the integration of all the Key Environmental Entities (B) with respect to any Issue of National Priority (A).

3. Any given Issue of National Priority (A) must be studied in a Context (D).

4. A Context for Environmental Education (D) consists of at least one Key Entity (B) imbedded in a specific setting of Environmental Interest (C).

5. Changing a Key Entity (B) or a Setting (C) changes the Context (D).

6. Holistic environmental education requires that a given Issue of National Priority (A) be studied in terms of several Contexts (D). Therefore, an Issue of National Priority (A) should be studied holistically by utilizing the minimum number of settings (C) necessary to convey all the Key Entities (B).

7. With the passage of time, changes can occur within Key Entities (B) and/or within Settings (C). Holistic environmental education is primarily concerned with the changes in the patterns of integration of the Key Entities (B) within Settings (C) over time, as they illuminate or clarify an Issue of National Priority (A).

8. The Content Specifications (E) facilitate the study of Issues of National Priority (A) in terms of the changing interactions of Key Entities (B) and Settings (C) over time, by describing how to focus dispersed clusters of concepts and principles into EE contexts.

9. The Curriculum Map (F) identifies the EE subject matter areas and processes associated with Content Specifications (E) and Key Entities (B). It specifies competences that the environmentally aware citizen must acquire in order to understand EE Contexts (D).

10. The Curriculum Map (F) can be used in either of two modes: integrative mode or reductive mode. In the integrative mode, the user begins with subject matter areas and cultural processes and builds up clusters of learning competences and EE principles/concepts that are related to a specific Context (D). In the reductive mode the user begins with a specific context (D) or set of EE principles/concepts and then identifies appropriate subject matter areas, cultural processes, and associated resources. In either mode, the Curriculum Map (F) informs the Context (D) with the information with which to build an instructional/learning arrangement.

From this initial set of protocols, a fairly comprehensive definition of the purposes of holistic energy/environmental education can be constructed. A general definition is:

> Energy/environmental education addresses the systems of humanity and nature as they interact in a values laden context.

A working definition in terms just defined is:

> Holistic energy/environmental education attempts to develop in learners (trainers, teachers, students) a broad and comprehensive understanding of: (a) how the key EE Entities are integrated within specific environmental contexts that involve issues of national priority; and (b) how the pattern of this integration changes over time due to either gradual or abrupt influences.

IV. A DESCRIPTION OF THE CONTEXTUAL MAP

Contextual Maps present conceptual models of relationships among the content areas that influence and describe an EE situation. The Contextual Map is an intuitive form of graphic presentation, since its structure and the visible connections it displays reflect the process by which it was made. The process of developing the framework for a Contextual Map has both a built-in "memory" and a certain "predictive" quality. These qualities are characteristics of the pattern of presentation structured by the framework.

The framework is not the Contextual Map. The framework is designed from the holistic definition of EE derived from the EE Act. The Contextual Map is constructed in the framework and depicts primary content areas which describe an EE situation and its relational aspects. This graphic manner of presentation and specification of content areas has evolved in response to the complexity and confusion generated under the rubric of environmental education.

The Environmental Education Act (as amended) calls for a holistic, trans-disciplinary approach to energy/environmental issues. The Contextual Map is consequently presented within the following framework, which depicts the most pivotal relationship of energy/environmental education as defined in the EE Act--i.e., HUMAN and NATURAL SYSTEMS INTERACTIONS. Thus, the three primary sectors in the framework are:

NATURAL SYSTEMS	INTERACTIONS	HUMAN SYSTEMS

The framework is further divided into CONCEPTUAL and OPERATIONAL domains, to enable us to explore the conceptual integrity and operational aspects of alternative sets of relationships among content areas.

NATURAL SYSTEMS	INTERACTIONS	HUMAN SYSTEMS	
			OPERATIONAL
			CONCEPTUAL

The content areas presented within each of the sectors therefore depict HUMAN and NATURAL SYSTEMS INTERACTIONS both at a CONCEPTUAL and at an OPERATIONAL level.

Consequently, we have two reflective dimensions of the NATURAL/HUMAN INTERACTIONS sectors which become increasingly CONCRETE and complex as one moves from both sides into the INTERACTIONS region.

NATURAL SYSTEMS	INTERACTIONS	HUMAN SYSTEMS	
			OPERATIONAL
			CONCEPTUAL

ABSTRACT → CONCRETE ← ABSTRACT

Where one "enters" the contextual map is, to a certain degree, arbitrary, because of the specified relational aspects. Science educators, for example, may wish to begin by addressing NATURAL SYSTEMS elements, while social science or vocational educators may begin with HUMAN SYSTEMS elements which focus on jobs.

The construction of Contextual Maps within this framework is useful in organizing the content areas associated with a specific EE situation, and is good assurance that a holistic and comprehensive treatment of the situation is designed into the instructional/learning materials and arrangements.

ENVIRONMENTAL EDUCATION ENTITIES

Environmental Education Entities are concept/topic areas that comprise the key focal points for environmental education. From a holistic understanding of the Entities, a definition emerges for holistic EE--to develop in learners an understanding of (1) how the key EE Entities are integrated within specified environmental contexts; and (2) how this integration among various Entities changes over time with respect to changing contexts.

The inclusion of the Environmental Education Entities into the Energy-Focused Environmental Education Teacher Training Model arises from Section 3.2 of the Environmental Education Act (PL 91-516, as approved October 30, 1970).

> For the purposes of this Act, the term "environmental education" means the educational process dealing with man's relationship with his natural and manmade surroundings, and includes the relation of population, pollution, resource allocation and depletion, conservation, transportation, technology, and urban and rural planning to the total human environment.

In 1978, Congress amended this Section to include "energy."

The Act and its hearing made it essential to stress that the environment is both the world of nature and the world fashioned by the activities of humans. Ironically, many contemporary problems have occurred as a result of our "successes" -- the achievement of our social goals. As the number and severity of these "problems of success" increase, so does the pressure to approach them in a systemic and future-oriented way. It becomes necessary, therefore, to structure an approach that will allow us to view the totality of interactions between the systems of humanity and nature. In this context, we will briefly describe the following Environmental Education Entities as part of a systemic approach to studying

Environmental Education situations:

- population dynamics
- pollution
- resource allocation and depletion
- conservation
- transportation
- technology
- urban and rural planning
- energy

Based on research and development efforts in the EE area, four additions have been made to this list. These additions are essential to the integration and understanding of the others. These additional entities are:

- environmental quality
- economic and technological development
- ecological balance
- environmental ethics

POPULATION DYNAMICS

Ehrlich, Paul R., Ehrlich, Anne H., and Holdren, John P. Ecoscience: Population, Resources, Environment. San Francisco: W. H. Freeman and Co., 1977.
Coverage of all topics in integrative environmental science. Introduction to basic ecological principles. Covers raw materials, energy concepts and problems, geophysical and climatological aspects of environment. Discusses the possibilities of social, political, and economic change. Population dynamics discussed in terms of ecological principles, and population is covered explicitly in relation to renewable and nonrenewable resources.

Hines, Lawrence G. Environmental Issues: Population, Pollution, and Economics. New York: W. W. Norton and Co., Inc., 1973.
Thorough discussions of the factors influencing worldwide population growth and movement. Covers relationships between population and gross national product (GNP) economics. Also discusses the concepts of zero population growth (ZPG), quality of life, and the impact of population on resources and food supply.

Miller, G. Tyler, Jr. Living in the Environment: Concepts, Problems, and Alternatives. Belmont, CA: Wadsworth Publishing Co., Inc., 1975.
This comprehensive text is in the format of two books. The first is a book of general ecological principles and concepts and their applications to major environmental problems. A large emphasis on the relationship between human environmental problems. A large emphasis on the relationship between human populations, resources and societal change. Secondly, a set of Enrichment Studies extend the basic concepts and add new topics. Important to the format of the book are guest editorials by twenty prominent environmentalists from a variety of disciplines.

Odum, Eugene P. Fundamentals of Ecology. Philadelphia: W. B. Saunders Company, 1971.
A classic ecology text. Includes the relationships between human and other natural system populations. Utilizes the principles of ecology to explain and discuss population dynamics as applied to human systems. See Chapter 7.

Olson, Mancur, and Landsberg, Hans H., eds. The No-Growth Society. New York: W. W. Norton and Co., Inc., 1973.
Arising out of a collaborative effort between Daedalus, The Journal of the American Academy of Arts and Sciences, and Resources for the Future, this book examines zero population growth and zero economic growth propositions. Includes selected readings on the aspects and possibilities of ZPG and ZEG, and their relationships to social structure.

Tuve, George L. Energy, Environment, Populations, and Food. New York: John Wiley and Sons, 1976.
See Chapter 2 for discussions of the relationship between population growth and world resources. Population movements and pollution are also covered. Discussion of zero population growth from a practical rather than philosophical viewpoint. Chapter 4 discusses food and food technology and the relationship between population, policies, and the supply of and demand for world foodstuffs.

POPULATION DYNAMICS

In the context of environmental education, it is necessary to describe population dynamics not only in terms of statistical amounts and rates of population change, but also in terms of the implications of population changes on natural and human systems. The major factors that can be shown to have direct bearing on the dynamics of population change are:

- birth rate: usually determined by the number of births per year for each 1000 persons in a population.
- death rate: the number of deaths per year for each 100 persons in a population.
- rate of population change: the birth rate minus the death rate. This rate is called the population growth rate if the population is increasing.
- fertility rate: the number of births per 1000 female population members who are of the childbearing age.
- age structure or age distribution: describes the composition of a population by the percentage of population in different age classes. Future population changes are directly affected by the age structure of a population.

These factors, together with knowledge of population densities and population movements (migration rates as determined by immigration and emigration), will give an indication of various impacts of manmade systems on natural systems. These natural systems of land, air and water are limited by inherent carrying capacities, that is, by their ability to process and/or store the liquid and solid wastes, heat, and various pollutants produced by human populations while remaining viable systems.

It is important to understand the relationships between human populations and the land and water required to satisfy even the most basic survival needs of shelter and food. When we add those human needs determined by the existence of social groups (e.g., transportation and services), the growth and movement of populations become factors that greatly influence environmental quality and quality of life. In holistic environmental education, therefore, the inclusion of population dynamics is essential to comprehensive understanding of natural-human system interactions.

POLLUTION

Barney, Gerald O., ed. The Unfinished Agenda: The Citizens' Policy Guide to Environmental Issues. New York: Thomas Y. Crowell Co., 1977.
This volume is the report of a task force on environmental issues sponsored by the Rockefeller Brothers Fund. It covers the regulation and policy aspects of water and air pollution, the hazards of toxic substances, the possibility of effective regulation of toxic substances, and the economics and financial priorities affecting pollution policy decisions.

Davies, J. Clarence III, and Davies, Barbara S. The Politics of Pollution. Indianapolis: Bobbs-Merrill Co., Inc., 1975.
An informative examination of pollution and its control. Gives definitions and explanations of different types of pollution, and devotes a chapter to current federal pollution control legislation. Majority of book deals with different policy makers' capabilities and responsibilities in pollution control, including Congress, the courts, and state and local governments. Also, chapters on research and pollution control standards, compliance, and enforcement.

Foin, Theodore C., Jr. Ecological Systems and the Environment. Boston: Houghton-Miflin Co., 1976.
An excellent text which covers basic ecological principles from a systems point of view. Includes sections on population growth, food production, land planning, and conservation. Excellent section on environmental quality with emphasis on pollution, its effects, and case studies of pollution control.

McCaull, Julian, and Crossland, Janice. Water Pollution. New York: Harcourt Brace Jovanovich, Inc., 1974.
One of a series of Environmental Issues from Scientists' Institute for Public Information. Comprehensive coverage of water pollution, including types, sources and control. Treatment and conservation efforts are also discussed in relation to controversial issues. Many case studies for reference.

Segerberg, Osborn, Jr. Where Have All the Flowers, Fishes, Birds, Trees, Water and Air Gone? New York: David McKay Company, Inc., 1971.
Recognition and discussions of natural and human-generated pollutions. Includes the more relative aesthetic considerations of noise and visual pollution, and litter. Also specific examples of pollution control and waste disposal policies.

Wagner, Richard H. Environment and Man, 2nd ed. New York: W. W. Norton and Co., Inc., 1974.
A text with thorough sections on the ecological traumas resulting from pollution. Explains the natural biosphere cycles, describes categories of pollutants and their effects on the parts and whole of natural systems. Also discusses radiation, its sources and effects, nuclear power, and radioactive waste disposal.

POLLUTION

A pollutant is any material or set of conditions that create stress on organisms or ecosystems beyond that found in normal environmental conditions.[1] A pollutant is not necessarily toxic. It may simply be too much, too fast, in too little space. Sediments, foodstuffs, poisons, and heat are constantly entering the air, land, and water, The living and nonliving elements of various ecosystems can handle certain amounts of each of these during certain periods of time. However, if humans deposit large amounts of these substances into the environment in a relatively short period of time, the natural system is unable to process or distribute them. The ecosystem is changed and ultimately destroyed.

Normal amounts of sediments, foodstuffs, poisons, or heat are not pollution. However, if they are introduced at a rate exceeding normal rate, or if they create or are part of any other environmental stress, then they constitute pollution. As such, pollutants or pollution can pose problems or threats to the balance and health of the environment, including human health. The types of pollution can be generally categorized into those that affect air quality, water quality, land-related resources, and environmental amenities. The following list includes natural and human-generated pollution that can result in increasing degrees of impact;

- nuisance or aesthetic insult
- property damage
- damage to plant and animal life
- damage to human health
- human genetic or reproductive damage
- major local, regional, or global ecosystem disruption

From an environmental education perspective, then, pollution is a direct measure of the interactions and impacts between the systems of humanity and nature.

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[1] G. Tyler Miller, Living in the Environment (Belmont, CA: Wadsworth Publishing Co., Inc., 1975), p. 267.

RESOURCE ALLOCATION AND DEPLETION

Barney, Gerald O., ed. The Unfinished Agenda. New York: Thomas Y. Crowell Co., 1977.
Section 4 in this volume focuses on the depletion of natural resources. It includes a discussion of re-use and recycling as means to conservation. Also discusses trends and projections in regard to the future of mineral supplies and the special problems of water resources.

Brown, Lester R. In the Human Interest. New York: W. W. Norton and Co., Inc., 1974.
Particularly geared to the relationships between population and dependence on non-renewable resources, Part III of this book provides a global social look at the consequences of resource depletion, including those resources that comprise food and material goods for the world's population.

Ehrlich, Paul R., Ehrlich, Anne H., and Holdren, John P. Ecoscience: Population, Resources, and Environment. San Francisco: W. H. Freeman and Co., 1977.
Introduction to all topics in environmental science. Complete coverage of ecological principles. Covers energy concepts and problems, geophysical and climatological aspects of environment. Also discusses the nature and possibilities of social, political, and economic change. Four chapters on the nature, use and mis-use of the earth's resources: land, water, and forests, food, energy resources, and materials for production (minerals and ores).

Steinhart, Carol, and Steinhart, John. Energy: Sources, Use, and Role in Human Affairs. North Scituate, MA: Duxbury Press, 1974.
A comprehensive discussion in Part 2 of the origins and nature of energy resources. Includes discussion of their uses to humanity, and the possible and current environmental problems associated with the use of both renewable and nonrenewable energy resources.

Tuve, George L. Energy, Environment, Populations, and Food. New York: John Wiley and Sons, 1976.
Examines the capacity limits of "spaceship earth" in terms of world resources, population, and technology. Comprehensive sections on renewable and non-renewable natural resources, including mineral, energy, and food resources. Future perspective on changing lifestyles and education for societal change is also covered.

RESOURCE ALLOCATION AND DEPLETION

A material or energy form becomes a resource or continues to be a resource because a technological innovation makes it available at a reasonable economic and/or environmental cost. The definition of a resource and the concept of an available, usable supply of a resource are therefore closely related to changing technological capability and economics.

Resources can be separated into two categories:

- Non-Renewable: a finite quantity of reserves that are made available to society as a function of available technology and capital investment. The depletion of non-renewable resources is dependent on the status of supply and demand for their use.
- Renewable: infinite reserves that are available at specific rates to humanity depending upon specific locale; their availability as an energy resource is also a function of available technology and capital investment. The depletion of renewable resources, then, is dependent on the rate at which they are used.

Important distinctions between these two types of resources are summarized below:

NON-RENEWABLE RESOURCES	RENEWABLE RESOURCES
• exist in the earth in limited quantities that could conceivably be used up	• will be available as long as the earth ecosystem continues to function
• comprise forms of high quality energy that have been historically easier to collect and use	• tend to be of higher entropy and require more effort and energy input for collection and use
• constraints on availability arise from the necessary energy required to pump or dig them up	• available for use as fast as they are supplied by the natural system -- for example, more wind or sunlight cannot be collected than passes through an area during a day

These distinctions provide a way to separate energy resources into renewable and non-renewable categories. This separation is exemplified in the following chart:

NON-RENEWABLE PRIMARY ENERGY RESOURCES	RENEWABLE PRIMARY ENERGY RESOURCES	
Petroleum	Solar	Radiant Solar Heat Photovoltaic Conversion
Natural Gas	Hydrological	Fresh Water Hydroelectric
Coal	Oceanographic	Tidal Temperature Gradient
Fissionable Materials	Geothermal	Steam Heat
	Wind	
	Life Forms	Human Photosynthesis Forests
	Recyclable Waste	

It is important to realize that the depletion of non-renewable resources is dependent on the quality and quantity of demands for which they are allocated, as well as on their supply or rates of availability. Goods and services are the visible results of a resource delivery system, which is one way to describe the series of processes needed to change a raw resource into useful work or end use. Questions of allocation, however, also bring up the social aspects of equitable distribution of and access to both primary resources and the goods and services produced from them. These types of considerations make it necessary to examine the entire resource system in order to maintain a holistic mode of inquiry in an environmental education situation.

CONSERVATION

Center for Science in the Public Interest. 99 Ways to a Simple Lifestyle. Bloomington: Indiana University Press, 1976.
An individual assessment approach to both qualitative and quantitative change in lifestyle. Focus on ways to conserve material and human resources, including food, fossil fuel, water, wildlife, and community or individual physical and psychological health. Each chapter has a brief discussion of the most important aspects of conservation strategies and specific measures to alter or create lifestyle patterns in these directions.

Darling, F. Fraser, and Milton, John P., eds. Future Environments of North America. Garden City, NY: Natural History Press, 1966.
This book is the record of a Conservation Foundation Conference in April, 1965. The collection includes contributor papers on organic ecology, economics, social and cultural purposes, regional planning and development, and organizational administrative considerations of conservation policy. All the readings are focused on the patterns of environmental change that affect environmental order and diversity, and include proposals for altering the manner in which humans take responsibility for conservation policy.

Dasmann, Raymond F. The Conservative Alternative. New York: John Wiley and Sons, Inc., 1975.
A broad examination of the issues involved in worldwide "environmentalism." Dasmann reviews present trends toward various environmental crises. Necessary conservation background information on biological systems and energy flows provides a framework for chapters on resource depletion, pollution, technocracy and land use. Case studies and examples in these areas and conservation strategies at both governmental and individual levels form the final focus.

Friends of the Earth. Progress as if Survival Mattered. Hugh Nash, ed. San Francisco: Friends of the Earth, 1977.
Subtitled "A Handbook for a Conserver Society." Each chapter is written by a specialist from fields including population and energy, public health, economics, parks and wilderness, oceans, mass media, international policy, and environmental law. The major focus of all chapters is on conservation strategy, with recommendations for specific conservation policy actions at the national level.

Fritsch, Albert J. The Contrasumers: A Citizen's Guide to Resource Conservation. New York: Prager Publishers, 1974.
Provides valuable guidelines for citizen participation in conservation efforts. Philosophical, ethical discussions of consumer and environmental attitudes, values and practices, and projections for the nature of a conserver society are covered in depth. Informative appendix is the Lifestyle Index, by which readers can calculate their personal energy expenditures and compare these with those from other nations. The index takes into account productive work, nourishment, recreation, cultural activities, and use and consumption of products of all kinds.

Wallace, David, ed. Energy We Can Live With. Emmaus, PA: Rodale Press, 1976.
Readings on specific "alternative" energy frontiers, agriculture and energy, household conservation measures. These articles are assembled from the best on energy and conservation that have appeared in the Rodale Press periodicals of Organic Gardening and Farming, Environmental Action Bulletin, and Compost Science.

CONSERVATION

The term "conservation" in environmental education is used to describe a broad decision- and policy-making position from which innumerable resource-conserving measures and strategies are generated. It should be understood that when we talk about resource conservation, we mean the conservation and "kindly use" of those materials, places, or energy forms that are *presently considered to be resources*. These are forming a growing list, as public concern and environmental policy encompass a greater territory at the local, regional, and national levels. For example, the National Energy Plan (April 1977), includes recommendations for a national energy conservation policy.

From the viewpoint of environmental education, it is necessary to create an informed citizenry that is willing and able to devise and implement conservation measures as the needs arise. These needs can range from simple energy-conserving measures, such as home insulation, to large-scale rationing, such as the water conservation that became mandatory during the 1975-1977 drought in California.

More importantly, it is necessary to instill a futures-oriented viewpoint that will form an *anticipatory* framework for the consumer and policy maker. To do this, conservation must be examined in an *integrative* fashion, which includes viewing the perspectives of economics, technology, scientific analysis of conservation measures, psychological aspects of conservation attitudes and behavior, and social implications of conservation policies.

This systemic view of resource conservation concepts, topics, and relationships enables us to understand which measures or strategies make the most sense in terms of potential energy or economic and environmental savings. Also, we can begin to take a long-term look at the possible consequences of various conservation strategies that are implemented at individual and aggregate levels.

TRANSPORTATION

Bendixson, Terence. Without Wheels: Alternatives to the Private Car. Bloomington and London: Indiana University Press, 1974.
Examines some specific new proposed transportation technologies, including the uses and limitations of such things as driverless vehicles, electronic guidance systems, and moving sidewalks. The author also looks at new ways to utilize existing vehicles, discusses new concepts in land use planning that could reduce the need to travel, and gives case studies of transportation experiments from all over the world. Finally, Bendixson discusses the manner in which new thinking and citizen input about transportation issues can change public policy and practices.

Burby, John. The Great American Motion Sickness (Or Why You Can't Get There From Here). Boston: Little, Brown, and Co., 1971.
The emphasis of this book is on transportation policy and the vested interests, directives, and public attitudes that have historically created and currently affect U.S. transportation patterns. Burby examines past and present modes of transportation, their relationship to metropolitan development and environmental degradation, laws and regulations and their effects on business, agency, and interagency effectiveness. He also discusses the history and role of the airlines, railroads, and public transportation in shaping national transportation patterns, and how new innovations and technological developments affect policy-making, taxation, laws and regulations. Burby is an advocate of public education on the systemic nature of transportation.

Illich, Ivan. Energy and Equity. New York: Perennial Library, Harper and Row, Publishers, 1974.
Examines how the overuse of energy for transportation not only increases wastes and pollution, but begins to destroy the relationships between people and cultures, giving rise to many social, economic, and political problems. Illich proposes solutions of a human scale, such as walking and biking, which are forms of transportation that foster more contact between people, and promote a different perspective of humanity through scale.

Owen, Wilfred. Transportation for Cities. Washington, D.C.: The Brookings Institution, 1976.
Owen expands on an earlier work, The Accessible City, by examining the advantages and shortcomings of recent federal programs to improve mobility in cities. He emphasizes that improvement requires not only more effective transportation systems, but also a halt to the decay of the central city and suburban sprawl. These are conditions that force people to use transportation as a means to escape and compensate for the inaccessibility of jobs, housing, shopping centers, and recreation. He compares alternative approaches that coordinate and optimize environmental influences, energy conservation, and transportation.

Saltonstall, Richard, Jr., and Page, James K., Jr. Brown-Out and Slow Down: A Citizen's Manual for the Twin Crises of Energy and Transportation. New York: Walker and Co., 1972.
Examines the U.S. transportation system in energy terms. It discusses problems and progress in mass transportation, the automobile and highways, urban transportation, and air transportation, as well as current events and proposals for new local, regional, and state transportation systems. Central to the theme of the book is the notion of the importance of citizen action and participation in energy/transportation issues.

Stone, Tabor R. Beyond the Automobile: Reshaping the Transportation Environment. New Jersey: Prentice-Hall, Inc., 1971.
Addresses the stress placed on one of the systems by which we obtain goods and services to satisfy human needs. Examines present methods of handling U.S. ground transportation and suggests an alternative approach based on the conclusion that our conventional methods cannot meet the demands of a growing population with shifting attitudes. The author takes the approach that attempting to meet transportation demands by current methods will prove more harmful than beneficial in the long range. The book offers a proposal for transportation commitments that considers social, environmental, and functional aspects, without emphasis on cost/speed economics.

TRANSPORTATION

The movement of goods and services is a primary step in the centralization of civilizations. The assemblage of people and services into urban configurations requires the development of transportation and storage systems to move the necessary commodities to a central location. Many urban problems arise when the enlarging transportation system creates a broader sphere of influence and provides access to people and services outside the central "place." Rather than a place to collect, the "place" becomes a site to disperse commodities, to go home from work, to leave for vacation.

Movement of people, goods, and services is necessary. However, both past and present modes of transportation are related to the impacts of metropolitan development and environmental degradation. In terms of the nation's highways, for example, we are presently in a runaway situation. We build more and wider highways that attract more traffic, promote the decay of mass transportation systems, and create a "demand" for more highways. These in turn allow even more traffic, and the cycle continues.

The history and role of airlines, railroads, and public transportation are integral in shaping national transportation patterns; and new innovations and technological developments affect policy-making, taxation, laws, and regulations. Economic situations and political organization affect and are affected by transportation business and industries, and the effectiveness of governmental agencies and interagency relations. For example, the relationships between the economic success of some forms of transportation and large fossil fuel industries is now common knowledge. Pollution and emission standards for transportation industries are constantly being revised. However, in order to examine transportation issues from a systemic viewpoint, it is necessary to question the basis for transportation needs and the implications of utilizing particular transportation systems for moving people and/or specific commodities.

TECHNOLOGY

Energy Technology to the Year 2000. Cambridge, Mass: Technology Review, M.I.T., 1972.

The ten articles in this book first appeared in three issues of Technology Review, a magazine of new developments in science, engineering, and their social effects. The categories of articles include the technological and social aspects of energy projections, energy and pollution, and energy sources and uses. This latter category of articles includes readings on transportation and power plant technology.

Hetman, Francois. *Society and the Assessment of Technology*. Paris: Organization for Economic Co-Operation and Development, 1973.

An integrative look at the philosophies, concepts, and problems associated with the development of "technological progress." Hetman creates a framework for a comprehensive assessment of "technology" as a whole, and of specific technologies. Discusses various experiments and methodologies of technology assessment, areas for the application of technology assessment, and the future uses and problems associated with the implementation of technology assessment into environmental evaluations.

Leckie, Jim; Masters, Gil; Whitehorse, Harry; and Young, Lily. *Other Homes and Garbage: Designs for Self-Sufficient Living*. San Francisco: Sierra Club Books, 1975.

Originated from workshops at the Stanford University School of Engineering on self-sufficient living systems. It represents an attempt by engineers and other technically trained people to communicate practical, useful, and technical information to non-specialized people. The focus of the book is to help the layperson gain the ability to design technologies that will allow the establishment of a more materially and energetically conserving lifestyle. Covers the area from background philosophy to highly specific directions for calculations.

Susskind, Charles. *Understanding Technology*. Baltimore and London: The Johns Hopkins University Press, 1973.

A thorough and comprehensive examination of the history, rise, and social effects of contemporary technology. Susskind discusses technology as a social phenomenon and an ethical problem. Includes the relationships between energy, electronics, transportation, communications technologies, the relationship between technology and health, the arts and humanities. These discussions form a framework for sample readings on the ideologies of technology.

TECHNOLOGY

It is now common knowledge that the sciences and technological advancements have made marked contributions to adapting the natural environments in which we live to social needs, by creating tools for shaping urban centers, agricultural systems, and information networks. The impacts of technological change have become important issues of public concern, as the often unforeseen and most unwanted effects become clearly evident. Some of these effects are direct, such as the obvious pollution and general degradation of the environment.

Others are indirect social consequences, are more subtle, and are therefore more difficult to measure. These are effects that arise from the societal adjustments required to accommodate and incorporate technological change. They include increasing dissatisfaction with education, business and government practices, and general changes in overall "quality of life." Many of these impacts are often directly attributed to "technology" itself, rather than to shifts in overall societal thought and goals.

An environmentally concerned public should be aware of two basic types of technological change. The first concerns the development of new technologies; the second involves the effects of new applications of existing technologies. In the context of environmental education, we can begin to understand the distinctions between those impacts directly caused by technology and those that have a deeper root in society. To do this, we can create a framework of information about the technology in question that is broken into two major areas: (1) that which addresses the nature of the technology itself, its technical structure and function; and (2) that which poses questions about the implications of the technology and its applications. This second category extends beyond the technical to the economic, political, social, and environmental consequences of technological impact. An environmentally literate citizen will understand these relationships and be able to apply this knowledge to the evaluation of technological issues.

URBAN AND RURAL PLANNING

Detwyler, Thomas R., Marcus, Melvin, and Contributors. Urbanization and Environment. Belmont, CA: Wadsworth Publishing Co., Inc., 1972.
An elaboration of seminars and faculty and invited experts' lectures from a University of Michigan experimental course on urbanization and its effects on the natural environment. It is useful to both concerned citizens and students as an information resource for planning. Discusses all the physical aspects of the urban environment, their possible effects on humans, and how humans affect them. Includes geology, climate, air pollution, water, soils, noise, and vegetation.

McAllister, Donald M., ed. Environment: A New Focus for Land-Use Planning. Washington, D.C.: National Science Foundation, October, 1973.
A comprehensive and useful compilation of working papers for a 1972 NSF-sponsored professional conference on environmental land use planning and research. The overview categories include a historical overview of land use issues and social, economic, and natural environmental factors important to land use planning. Particular emphasis is on the application of urban and natural environmental sciences to land use planning strategies.

McHarg, Ian L. Design with Nature. Garden City, NY: Doubleday and Co., Inc., 1969.
McHarg's book is considered a classic description and application of an ecological approach to land use. A framework based on the carrying capacity analysis of the land region in natural and human system terms is integral to this approach. McHarg demonstrates how this type of knowledge and method is applied to caring for natural environments such as swamps, lakes, and rivers; choosing sites for urban development; re-establishing human norms and integrative life in metropolitan areas. Many detailed and helpful diagrams, photos, maps.

Stearns, Forest W., and Montag, Tom, eds. The Urban Ecosystem: A Holistic Approach. Stroudsberg, PA: Dowden, Hutchinson, and Ross, Inc., 1974.
Originated from a workshop--the Urban Ecosystem Project of the Institute of Ecology, 1972. The major principle of the volume is that urban problems can be solved or prevented altogether if the knowledge of ecological interrelationships between people and urban environments is transmitted to, and utilized by, those responsible for urban planning and management It is written in two parts. The first is a philosophical base and framework of goals and values, from which come recommendations for policy-makers. The second part examines in detail the components of an urban system from an ecological viewpoint, and includes methods for analysis, and case-studies of policy-formation in cities across the U.S. Many diagrams and examples for clarity.

Whyte, William H. The Last Landscape. Garden City, NY: Doubleday and Co., Inc., 1968.
William Whyte has been an active and effective force in the passage of open space statutes in many states. In this book, Whyte examines metropolitan areas for their potential as high quality environments, where land is used and/or saved as an integral part of the urban system. Emphasis is on past experiences and case studies of land use legislation and design plans, including the range from "greenbelt plans" to inner city "New Towns," scenic roads and play spaces.

URBAN AND RURAL PLANNING

The concerns of urban and rural development extend far outside city limits or agricultural areas; planning trends and policies influence the majority of Americans. From any standpoint, it is evident that new and expanded human settlements will be required to accommodate and support our increasing population. In both public and private sectors, there is continued disagreement over how growth should proceed in order to accommodate population pressure while placing minimal stress on either natural systems or overall quality of life.

All urban and rural environments involve the use of natural resources, some of which are in relatively short supply. Examples of these are: clean air and water, land for urban use and agriculture, fuel resources and amenity resources.[2] Therefore, from an environmental education perspective, it is advantageous to examine the environmental quality of urban and rural areas in terms of: (1) their relationship to natural systems, and (2) the overall "quality of life" of their residents. These evaluations take into consideration not only the land use of these areas, but also the diverse social interests, economics, energetics, and political considerations involved in planning issues.

In this context, it is useful to describe planning as an activity centrally concerned with the linkage between knowledge and action. This type of definition helps us to find a common ground for discussion which will allow environmentally literate citizens of broad interests to work toward sensible policies and practices.

A system of anticipatory planning for urban and rural areas is essential to increase the power and authority of public participation in planning activities and policy-making. This approach gives us the ability to be systematic and to predict--not necessarily the exact results of planning decisions, but their implications and possible consequences of success or failure.

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[2] Amenities are those aspects of the environment that serve to increase standards of growth and "peace of mind." These include open space and recreational opportunities, adequate and available public buildings and services, diversity and availability of cultural opportunities, visual access to natural and/or pleasing views, and convenient access to desired facilities.

ENVIRONMENTAL QUALITY

Clarke, Ronald O., and List, Peter C. Environmental Spectrum: Social and Economic Views on the Quality of Life. New York: D. Van Nostrand Co., 1974.
Consists of published revisions of papers that were initially presented at a public symposium at Oregon State University in 1973. These papers are the result of the interactions of economists and environmental scientists with the citizens of several Oregon communities. Focus is on the relationships between economic growth, lifestyle, environmental impact, and quality of life.

Faltermayer, Edmund K. Redoing America. New York: Collier Books, 1968.
Although not recent, this book is a thorough discussion of the environmental quality of metropolitan areas. The author examines problems such as air and water pollution, and land use and misuse in the suburbs. Includes discussions of proposed solutions, available governmental agencies, and how private business can contribute to increasing envrionmental quality.

Hinkle, Lawrence E., and Loring, William, eds. The Effect of the Man Made Environment on Health and Behavior. Washington, D.C.: U.S. Government Printing Office, #DHEW (CDC) 77-8318.
The papers in this book cover a broad range of health factors as related to metopolitan environments. Includes both philosophical background and studies of particular physcial and psychological problems related to environmental change. Book is useful to preventative health professionals, land-use and urban planners, and professionals in recreation and social work.

Wang, J.Y., Hemmer, William B., and Tuttle, Frederick B. Exploring Man's Environment. Palo Alto, CA: Field Educational Publications, Inc., 1973.
Concepts and problems in environmental studies are the basis of this book. A thorough examination of natural and human interactions in three major parts: (I) The Environment of Man, includes discussions and descriptions of all natural systems; (II) Human Environmental Problems, pollution, land use, resource depletion, solid waste, toxic substances, and energy; and (III) Cultural and Technological Remedies, technology and its impacts, economic, political and cultural impacts of environmental problems.

U.S. Environmental Protection Agency (U.S.E.P.A.). Promoting Environmental Quality Through Urban Planning and Controls. Washington, D.C.: U.S. Government Printing Office, February, 1974. #EPA-600/5-73-015.
Title is deceptive. Actually, this document is extremely thorough on a regional level of environmental quality control. Reviews mainstream practices and orientations of the 1960's in planning areas related to environmental quality. Reviews and makes recommendations on more promising and innovative approaches to the following environmental quality planning sectors: land use and comprehensive planning; planning and controls for water resources-land use interface; design and controls for urban environments; residues management (noise and air quality). Volume is of use to concerned citizens as well as current planners and government officials.

U.S.E.P.A. Quality of Life Indicators in U.S. Metropolitan Areas, 1970. Washington, D.C.: Washington Environmental Research Center, 1975.
A notable study. A presentation of a systematic methodology for constructing, and the results of assessing, economic, political, environmental, health and education, and social indicators in 243 metropolitan areas in the U.S. The findings and implications of these assessments are easily read, and charts and figures are not difficult to interpret.

ENVIRONMENTAL QUALITY

For the purposes of environmental education, it is important to hold a systemic view of a quality environment. To do this, we can examine and evaluate two interconnected areas: (1) the quality or status of particular natural systems; and (2) the quality of life of the inhabitants in these systems.

It is important to describe the notion of environmental quality in a manner that addresses more than just the impact of pollution or development. It is necessary to examine how we, as humans, affect the manner in which energy, materials, and information interconnect and flow through different ecosystems, and how these ecosystems in turn affect us.

The environmental quality of natural systems is usually a direct, visible result of natural and human system interaction. An evaluation or assessment of the natural systems would include aspects such as the following, considered on both a short- and long-term basis:

- observable or hidden effects on air quality, including those caused by pollutants, heat, or odors;
- observable or hidden effects on water quality, including those caused by pollutants or radioactivity, and ground water impacts or climate modification; and
- observable or hidden effects on critical land-based resources, such as mineral-bearing or forested lands, agricultural lands or biological systems.

Human environmental quality is more difficult to perceive and measure. Many surveys and studies have been conducted recently on the "quality of life" in numerous areas of the United States. All are attempts to describe the same subjective attitude from different points of view. Most people would agree that their own quality of life is relative to some ideal state of living conditions, often directly related to the state of the nearby natural system. Determinants of quality of life are situational variables, meaning that they change with place, time, and the values of the people being surveyed.

ECOLOGICAL BALANCE

Clapham, W. B., Jr. Natural Ecosystems. New York: The Macmillan Co., 1973.
A broad look at the components and nature of ecosystems. Discussions of energy and material cycles and flows through the earth's natural systems. Considers environmental factors and their effects on populations and vice versa, and the importance of the structures and patterns of communities. Chapters on specifics of aquatic and terrestrial ecosystems. Important chapter on the resiliency and adaptability of ecosystems, their responses to environmental disturbances, and the importance of "ecosystem fitness" to the maintenance of dynamic equilibrium. Good diagrams and charts.

Greenwood, Ned H., and Edwards, J.M.B. Human Environments and Natural Systems: A Conflict of Dominion. North Scituate, MA: Duxbury Press, 1973
Begins with discussions on the relation of finite land and resources to human populations and their needs for sustenance. Fuels and energy use, food, and the wastes of materials and energy production are covered. Also, urbanization, open space, the necessity for wilderness and wildlife preservation, and quality of life in relation to these aspects. The final sections focus on optimum population, ZPG, environmental controls, and the importance of education, a survival ethic, and national policies for maintaining worldwide ecological balance.

McHale, John. The Ecological Context. New York: George Braziller, Inc., 1970.
Complete and comprehensive examination of the ecological orientation of "planetary housekeeping." Includes the social behaviors of humans in the coverage of physical and biological concepts. Introduces major principles of ecology and ecological balance, the relationships of humanity and nature, population and food, energy, materials. A proposal of long-range "ecological redesign" of our technological systems to be more compatible with the overall ecological system. Selected reading lists for seven major categories related to the chapters in the book.

Odum, Eugene P. Fundamentals of Ecology. Philadelphia, PA: W.B. Saunders Co., 1971.
This is a complete text on natural and human ecology, which incorporates three books into one. The first book presents a macroscopic view of the field of ecology as it relates to human affairs. These chapters provide a review of ecology for the concerned citizen, students, professionals and scientists, government officials, or people working in industry. The second book is geared to the undergraduate college course in ecology with laboratory and experimental work recommended. Book number three--which is the entire volume--is a comprehensive reference work on principles, environments, and ecological technology and is a textbook for graduate courses.

Russwurm, Lorne H., and Sommerville, Edward, eds. Man's Natural Environment: A Systems Approach. North Scituate, MA: Duxbury Press, 1974.
This collection of articles is pulled from a wide variety of sources and disciplines. Organized according to a systemic view of the environment. Emphasis is on natural systems, and the flows of energy, water, nutrients, and other matter within and between subsystems. Russwurm's systemic framework is based on the recognition of the feedback and diversity processes that keep natural systems in equilibrium.

ECOLOGICAL BALANCE

Many people often view the "balance of nature" as a phenomenon that does not change over time. However, the processes of ecosystem development are dynamic--they are constantly adjusting to environmental change, both beneficial and harmful. The balance of the system is maintained, not as the result of sameness, but as the result of this dynamic change and adaptation. The communities that make up an ecosystem are continually changing in response to the internal pressures caused either by the interaction of the communities themselves (e.g., overpopulation) or by external stress (e.g., fires, flooding, erosion, farming, industrialization, pollution, and urbanization).

In general, the activities of humanity have been geared toward maximizing the production of natural ecosystems. Here we find increasing conflict between the goals of humanity and the natural strategy of ecosystem development. In order to evaluate ecological balance from the EE perspective, we can examine the relationships between the following general types of ecosystems:

- mature natural ecosystems: ecosystems that are more or less in their natural states, generally unused and uninhabited by humans (for example, wilderness areas, mountains, deserts)
- managed natural ecosystems: ecosystems that are managed by humans for recreational use or for the production of natural products (for example, parks, managed forests, hunting areas, some ocean areas)
- productive ecosystems: ecosystems used by humans for the intensive production of food, fiber, or natural resources (for example, farms, cattle ranches, energy resource reserves)
- urban ecosystems: ecosystems in which humans live and work (industrial areas, cities, towns)

It is necessary to maintain an informed respect for the dynamic stability of these systems, internally and in relation to each other. A knowledge of the workings of whole ecosystems is necessary to environmental decision-making with respect to the interactions between humanity and nature.

ECONOMIC AND TECHNOLOGICAL DEVELOPMENT

Clark, Wilson. Energy for Survival. Garden City, NY: Anchor Books, 1974.
Examines a multitude of energy principles and concepts, based on the assumption that Western civilization has been dependent for too long on finite energy resources. Detailed and comprehensive discussions of the energy basis of industrial civilizations and the rise of the American high-energy society. A large section specifically devoted to the relationships between energy use, technology, technology assessment, and society. Thorough examinations of future energy resources and technologies as a basis for scenarios for future energy use in society.

Daly, Herman E., ed. Toward A Steady-State Economy. San Francisco: W.H. Freeman and Co., 1973.
A collection of essays on the thesis that economic growth for growth's sake is destructive and unsustainable. Essays include consideration of alternatives to "growthmania" as well as criticisms of it. Topics range from physics to theology, but the main emphasis is on political economy. Contributors include Paul Ehrlich, Kenneth Boulding, Garrett Hardin, Nicholas Georgescu-Roegen, and C.S. Lewis.

Henderson, Hazel. Creating Alternative Futures: The End of Economics. New York: Berkly Publishing Corporation, 1978. Forward by E.F. Schumacher.
Contains the collected writings of Hazel Henderson, who is a futurist, a philosopher, an activist, and a founder of many public interest organizations. Essays are based on the current social transformations that people are undergoing--rethinking their jobs, their relationships, and the function of the local community, the state, national, and global communities. Part One--The End of Economics--includes essays on economic logic, resource policy, entropy, inflation, and growthmania. Part Two--Creating Alternative Futures--offers solutions and new approaches to social mediation, the uses of mass media, effective citizen participation, technology, technology assessment, and global equity.

Schumacher, E.F. Small is Beautiful: Economics as if People Mattered. New York: Harper and Row, Publishers, 1973.
A collection of essays from the late E.F. Schumacher. Calls down the assumptions of the industrial view of "economic science" to their psychological and philosophical foundations. Schumacher explains an economics that supercedes the considerations of "productivity" and the economic index. Tracing the problems of production and the role and scale of appropriate economic endeavors, the author covers the relationship of economics and technology to resource and land use, and worldwide social problems of economic and technological development.

Scientific American. Energy and Power. San Francisco: W.H. Freeman and Co., 1971.
The chapters in this book originally appeared as articles in the September 1971 issue of Scientific American. They cover both conceptual and technical aspects of energy technologies, including energy throughout human history. Articles address the flow of energy in the various cultural forms of hunting, agricultural, and industrial societies. Other articles include discussions of the economic geography of energy, energy and information, and decision-making in the production of power.

ECONOMIC AND TECHNOLOGICAL DEVELOPMENT

The Environmental Education Act Amendment explicitly includes the necessity for consideration of the relationships between the impacts of environmental, economic, and social concerns. In this context, we can examine the development of cultures in terms of their technological and economic changes, in relation to their environmental resource base.

The history of humanity can be looked at in terms of energy, technology, and economics--both the discovery of principles and the invention and marketing of tools designed to improve living and working conditions. This is particularly the case in industrialized cultures such as the U.S., where notable periods of history have been characterized by events that were considered to be bridges to further development, such as the development of the steam engine, or the integrated electronic circuit. We can discern four major periods of cultural history that were made distinctive by the discovery of important principles or the invention of important tools and technologies. These periods are:

- hunter-gatherer society, in which the discovery of fire was made;
- agrarian society, in which the technology of cultivation made possible the first permanent social groupings;
- pre-industrial or advanced agrarian society, which includes the Middle Ages and the Renaissance, and the introduction of capitalism as a permanent social form; and
- industrial society, exemplified by the Industrial Revolution, which offered abundant opportunities in agriculture, transportation, and national industry.

Many observers contend that we are now beginning the fifth period, a post-industrial society, where we are locking to alternative technologies and changes in economic growth patterns.

A systemic evaluation of economic and technological development--past, present, and future--must examine the relationships between technologies and political structure, law, economics, and social structures. This includes the "problems of success" caused by advances in technology and human ingenuity, which can be anticipated through utilizing a holistic EE perspective.

ENVIRONMENTAL ETHICS

The Environmental Education Act addresses the need for responsible, informed public support of and participation in policies and programs, decisions and actions concerned with environmental quality. It is essential for effective citizen participation that there be an understanding of the prevalent moral attitudes, principles, and values (i.e., ethics) that shape environmental policy. To create this understanding, we can examine the development of prevalent worldviews as a basis for policy evaluation. A worldview exemplifies a set of ethics, based upon beliefs about the basic nature of humanity, nature, and the universe--what we assume to be true, and what we hope or think will become true.

For some two hundred years, the industrial worldview has dominated and shaped major goals, priorities, and social structures throughout the Western world. Recently, many observers and analysts of societal and cultural developments have interpreted the present period of rapid change as indicative of a major break with past standards, perceptions, and assumptions about the nature of the world and humanity. In other words, we are currently undergoing a shift in worldview. As such, a change of this magnitude will have a fundamental effect on social, political, economic, and technological interrelationships, and will have direct implications for energy and environmental policy and practices at the individual and aggregate levels.

Conflict generally arises over the focal points of the emerging worldview that address the following tenets:

- the resources of the world are finite;
- the individual's responsibility is to manage his or her life and property with proper regard to the rights of others, including the "rights" of natural systems; and
- humankind should be guided by a principle of equity, in terms of the distribution of resources, and social and environmental quality.

ENERGY

Clark, Wilson. Energy for Survival. Garden City, NY: Anchor Books, 1974.
Clark analyzes the relationships between energy and society, particularly the development of Western industrial society. This work is based on the assumption that current energy development and exploitation of resources cannot continue for long, due to the finite nature of most current energy resources. Clark examines the historical nature of high energy society, limits to economic involvements in energy development, decentralization of electrical power, and energy resources, past and future. Particular emphasis on solar-based power systems, including indirect and direct solar technologies, from hydroelectric power to bio-conversion.

Dix, Samuel M. Energy: A Critical Decision for the United States Economy. Grand Rapids, MI: Energy Education Publishers, 1977.
A thorough look at the basis for energy policy decisions in the U.S. Includes a helpful discussion about differing points of view on the "energy crisis." Separate sections on case studies, figures, and forecasts for energy resources that have a major part in U.S. energy policy. Also discussions of energy industry outlooks and economics of energy policy.

Energy Policy Project of the Ford Foundation. A Time to Choose: America's Energy Future. Cambridge, MA: Ballinger Publishing Co., 1974.
The report of a two-year inquiry into the status of the U.S. situation. Its authors--economists, lawyers, writers, scientists, and engineers--were brought together by the Ford Foundation to attempt to identify the nation's energy policy choices. The group presents three scenarios of projections for policy making choices, and discusses its recommendations for policy in terms of employment, economics, private enterprise, electric utilities, energy resources, and energy research and development.

Lovins, Amory B. Soft Energy Paths: Toward a Durable Peace. San Francisco: Friends of the Earth International, 1977.
Lovins is a pioneer in setting up the practical thesis for a transitional move to "soft technologies" based on net energy. This means using direct solar energy, wind, and biomass conversion within half a century to meet the needs of a society that at the same time is using existing systems as a bridge to the future. Describes the societal changes needed to carry through resource conservation, suiting types of energy to the nature of their end use. Lovins' discussions are based on documented technical information and highly developed energy supply and cost analyses.

Odum, Howard T. and Odum, Elizabeth C. Energy Basis for Man and Nature. New York: McGraw-Hill Book Co., 1976.
This book is aimed at the general public, political leaders, and students who may need a short and concise statement of the principles of energy and the way these shape our culture--past, present, and future. The book includes patterns of systems, basic laws of energy, and alternatives for energy futures. Emphasis on Odum's energy diagramming symbols and techniques to trace energy flows and cycles through natural and human-created environments.

Steinhart, Carol, and Steinhart, John. Energy: Sources, Use, and Role in Human Affairs. North Scituate, MA: Duxbury Press, 1974.
A comprehensive, systemic approach volume on all aspects of energy. Discussions of the energies in nature and history, energy principles, energy sources and their uses, energy prospects for the future, and energy policy. Includes a glossary of energetics terms and appendices on specific energy functions in natural and human systems.

ENERGY

We hear the term "energy" constantly in the media. We know intuitively, that there is something "out there" (and internal, as well) that keeps our personal and societal process of activity and involvement going every day. We feel that energy is something definable, yet it is difficult to find a definition that is agreeable to everyone. For the purposes of environmental education, we feel the simplest definition is the most inclusive. Energy is a capacity to do work or bring about change. Energy, in this sense, includes not only naturally and humanly developed resources; but also materials, goods, and services, which contain energy in many forms.

We live with the assumption that energy in its various forms is good for something, that it is essential in performing certain work-requiring tasks. Historically, Western industrialized civilization has attempted to dominate and control nature. What measure of success it has been able to effect has been due to this harnessing of energy for work. However, until recent events such as the Arab oil embargo, the findings of DDT in ocean life, and the popularization of the notion of space colonies, most people were not very concerned with how we obtain our energy, what it is used for, or what effects occur due to its use.

The list of energy/environmental issues that could be discussed is almost endless: the impact of technology, urbanization, land use and open space, conservation, and pollution of all kinds are simply those that are the most visible. However, all of these issues can be examined in terms of the relationships between energy and the work it performs. In environmental education, we can form a systemic framework for asking the right questions about energy, energy resources, and energy delivery in order to have a solid basis for personal decision-making and policy formation.

ISSUES
OF
NATIONAL
PRIORITY

In environmental education, it is basic that the educational effort be aimed at improving citizen awareness and understanding of energy and environmental issues at the national level. The opinions people have affect public policy; governmental, administrative, or legislative action is in large part determined by what the majority of people perceive as the issues of national priority.

As an introduction to a manner in which national issues may be examined in an integrative context appropriate to environmental education, this section will present two current views of important national issues--as of 1977-78. First, it will present an overview of issues as determined by analysts of the current national and international situation. These issues are identified in forecasts, trend analyses, projections, and predictions, and they generally include *pre-critical*, future-problem-area issues, as well as those issues already in evidence.

The second type of national priority viewpoint comes from a study of popular journals, those that are read by many types of people from many different fields, including university audiences, business and industry, and government.[1] Rather than being projective or predictive, this type of coverage of national issues tends to feed popular interest and public opinion, and is cyclical in nature, dependent on those crises that are immediate, rather than on long-range concerns. There is some future-thinking involved in public opinion, but public interest is more closely tied to concerns that can be projected to have effects in an individual's own lifetime, or in the lifetime of his or her children. These concerns also tend to be highly connected with individual economics, the effect on the "dollar in the pocket."

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[1] Journals used in the study include: *Atlantic Monthly*, *Esquire*, *Fortune*, *Harpers*, *Harvard Business Review*, *Intellect*, *National Review*, *Nation's Business*, *New Republic*, *The Progressive*, *Scientific American*, *Smithsonian*, and *Vital Speeches*.

As a way in which to compare the two current views of issues of national priority, this section will address areas of overlap, and will indicate possible reasons why other areas important to some are not currently of popular interest. This approach can provide a general mode of investigation, examining the similarities and discrepancies between forecasts from a multidisciplinary group of analysts, and examining popular interest in the same general areas. It is useful to note some differences that are inherent in this type of comparison. Most studies and analyses are not readily available to, or understandable by the general public, due to their specificity. Therefore, what is covered in journals directed toward a more general audience:

- reflects a lag time of varying amounts, due to the publication or distribution of studies to the journalism community;
- reflects the crises or events currently occurring and impacting on large segments of the general public; or
- is often be the kind of coverage that will begin to formulate or direct public interest in these areas.

To reiterate, the purpose of this section of the Content Sourcebook is to provide an overview of the relationships between overriding issues of national priority and their treatment and understanding by the general public. This relationship is integral to environmental education efforts in that it provides one context in which to design holistic, problem-focused EE curricula.

BARRIERS TO LARGE-SCALE TECHNOLOGICAL PROJECTS

Undertaking large-scale technological ventures such as building intercontinental railroads or going to the moon has always been a difficult and complex process. Modern industrial nations are finding it more difficult than ever to carry out important projects in transportation, energy, food production, environmental protection, and housing. This has become particularly evident in capital-intensive undertakings such as dams, transit systems, and power plants. The Bay Area Rapid Transit (BART) in San Francisco and the Concorde Supersonic Transport (SST) project are notable examples of large-scale projects that have fallen short of their promised services and/or have proven far more costly than predicted in original or even secondary projections.

Some large-scale projects may soon become vital to supporting or transporting the earth's populations. These include synthetic fuel plants, desalination facilities, urban transit, biomass production, and advanced airliners. Some are projects that explore frontiers outside the earth. These include space probes, manned space flights, and space colonies.

The difficulties in implementing these projects seem to stem from their scale, but are manifested in political, economic, and social dimensions rather than in terms of technical capabilities or organizational structures. Because of their size and long-range effects, these projects often require public financial support, which involves either direct or indirect public approval, and political accountability. Because of recent.evidence of large-scale project failures, however, there is a growing disbelief in promised benefits. This discourages both public and private willingness to invest tax dollars or to share control through government subsidy or tax incentives.

Widespread public concern is accompanying the development of nuclear power, and its major implications for the national and international situation. This rise in public interest stemmed mainly from President Carter's pre- and post-election National Energy Plan announcements.

Different journals show us the diversity of opinion regarding just this one issue of large-scale technology. For example, business and industry have been confronting the rising costs and increasing governmental regulations of nuclear power installations. Articles in Nation's Business (January 1977), The New Republic (February 25, 1978), and the National Review (September 16, 1977), discuss the problems facing the energy industry in the production of nuclear reactors. These problems include the National Energy Plan and its lessening dependence on nuclear power, increasing costs of production, increasing costs of remedies for operational and maintenance problems, and the effect of environmental concern and activities on public opinion.

Popular scientific publications address a different set of concerns. The 1977 issues of Scientific American, for example, carried articles on technical aspects of reactor production problems, nuclear fuel alternatives, and nuclear waste disposal sites. Most of these articles centered on aspects of breeder-reactor power stations. (Scientific American: March, May, June, July, August, 1977). Although written as informative, technical articles, they proceed with the understanding that

> "...public acceptance and institutional adaptation may be more difficult than technical considerations...commercialization before the end of this century will require the active support of diverse interest groups if the long lead-time discussions and commitments are to be made..." (Scientific American, March 1977, p. 58)

Journals of the same month are presenting different views on the same issue. An article in Fortune magazine (September 1977) presents arguments for the development of the breeder reactor, while the Progressive of the same month focuses an entire issue on anti-nuclear sentiments. Both of these articles, as well as an article in Atlantic (April 1977) discuss the possibilities of terrorism and nuclear proliferation in relation to the international development of nuclear power.

Space exploration and space colonies, although of large-scale technological nature, are not currently treated in the same manner. They are still too far from the public view and/or common understanding of the technologies to be converted to popular jargon. However, children and youths are growing up with constant exposure to the notion of traveling and settling in space. It will be useful to realize that this view may have great implications on education and the public opinion in the near future. Currently, most technical journal emphasis is on the use of space technologies to provide energy for earth--e.g., the mining of minerals on the moon, or beaming concentrated solar energy from satellites. Not much space has been given to these ideas in recent popular literature as of yet. One article, however, in the Smithsonian (December 1977) did discuss the prospects of building electric power facilities in space and of creating factories for metals and medicines.

Few other large-scale projects have been given popular exposure where they could be examined for their immediate economic, political, or social effects.

CUMULATIVE EFFECTS OF POLLUTION

This issue is probably the most visible to the widest range of the populace. People notice air and water pollution, for it affects their immediate comfort and health. However, it is important to understand and maintain a longer-range outlook than one that is crisis-dependent. We know that as new industrial processes develop and new technologies make it possible to manufacture new products, the number and amounts of new chemical compounds released into the environment increase. According to one study, there are over 5000 new compounds developed each year, and at least 1000 of these find their way into the biosphere as pollutants.[2]

Because of possible cumulative or delayed effects of many chemical pollutants and radioactive waste materials, the effects of these new compounds on human health and on the stability of the ecosystem may not be evident for years or even for generations. For example, it took many years for the effects of some aerosol propellants on the ozone layer of the atmosphere to be discovered, and only recently has the relationship between mercury poisoning and the mercury content of fish become an issue for regulation. There may emerge widespread outbreaks of environmentally-induced physical or mental health problems, or chronic ailments that will not be easily susceptible to treatment. The causes of such diseases would be so far in the past as to prevent any new corrective measures. Treatments would have to remain symptomatic rather than preventive.

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[2] Stanford Research Institute, Center for the Study of Social Policy, Assessment of Future National and International Problem Areas, vol. I, (Washington, D.C.: National Science Foundation, February 1977), p. 89.

There are currently no adequate methods or capabilities for monitoring and tracking pollutants through the environment, characterizing interactions with other chemicals, and assessing their potential for inducing health or behavioral changes. These factors have an impact on the effectiveness and problems of regulation and control of toxic substances. For example, the accidental or deliberate introduction of toxic materials into water supplies is of major concern to some analysts. This is due to the complexity of modern water supply systems, the large populations they serve, and the dependence on water of agriculture and food production. When rapid and efficient regulation of toxic substances is difficult, or encounters institutional barriers, the possibility of future health problems is even greater.

It is relatively easy to find examples of this issue as treated in recent journals. For example, in the Atlantic (March 1977), an overview article reviews several of the pollutant "crises" of the last decade, why they were called to public attention, why some have fallen from the public view, and their status in terms of change or control. These include the effects of DDT, cyclamates, mercury in fish, the ozone controversy, damage to the lungs of asbestos workers, defoliant conflicts, and discoveries of the effects of chemical food dyes.

The February, May, and August 1977 issues of the Progressive all carry articles pertaining to various types of pollution and their effects. Both the February and May issues focus on "chemical catastrophes"--mainly the widespread and possible long-term effects of toxic PCBs (polychlorinated biphenyls, used as coolants and in other similar ways), and PBBs (polybrominated biphenyls, used as fire retardants) when distributed through contaminated foodstuffs. The August issue contains an article about the radioactive elements in common household smoke detectors.

An article in Scientific American (January 1978) is concerned with the long-term implications of increased carbon dioxide in the earth's atmosphere, seemingly due to the human activities of burning fossil fuels and the worldwide destruction of forests. The journal Vital Speeches of the Day carries different viewpoints on toxic substances. For example, one article describes an industry view of chemical substance development and the public reactions to crises involving toxic substances (Vital Speeches, April 15, 1977). A later issue describes a view of the effects of the Toxic Substances Control Act and its relation to governmental and self-regulatory control in the chemical industries (Vital Speeches, March 1, 1978).

Currently, then, many aspects of the national issue of cumulative effects of pollution are in the public view as presented by popular journals. These aspects include short- and long-term health considerations, short- and long-term environmental considerations, chemical substance development, and industry and governmental regulation of toxic substances.

REGULATORY CONSTRAINTS AND ECONOMIC GROWTH

Increasing appreciation of national and international needs such as pollution control and resource conservation seems to have resulted in the improved organization of special interest groups with higher levels of public support, and a distrust of large institutions. These trends often result in the introduction or instrusion of non-economic considerations into the free operation of the economy. This is exemplified by regulations imposed through legislative processes. Specifically, these regulations arise from such forces as the following:[3]

- Progressive degradation of the environment by the waste products of industrialized society;
- High rate of introduction of new synthetic chemicals whose long-term effect on humanity and the environment may not be known for generations;
- The need to take anticipatory actions regarding resource depletion in advance of market-response price increases, especially in the areas of fuels, minerals, and arable land;
- Possible threats to natural ecological systems and the life-support systems of the earth;
- Amenity, ecological, health, and aesthetic impacts of large energy- and resource-related projects; and,
- Aggravated distrust of business and increasing doubt that the economic criteria of business decision-making are leading society to good social choices.

Regulations arising from such forces often create problems that are worse than the original problems. The results of the application of regulations in some cases lead to the necessity for even further regulation. In some instances, regulations reduce productivity, and the lag times of implementing regulations have frustrated plans based on millions of research and development dollars. In other instances, regulations have driven up the costs of products with questionable benefit to the consumer, or have discouraged free enterprise by increasing costs of production. Also, regulation could be restrictive enough to eliminate development of significant resources, such as oil shale, and to increase costs in such ventures as coal mining.

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[3] Center for the Study of Social Policy, Assessment of Problem Areas, p. 66.

The diverse pressures for regulation of the economy are so inconsistent that they inhibit systemic long-range planning. The need for regulation and the requirements of a healthy economy may necessitate major trade-offs in order to create a business environment that is not so restrictive that it will seriously cripple and inactivate the economy.

Articles in journals tend to exemplify or address the forces affecting regulation. Recent examples include some that reflect concerns about transportation regulations and their effects on the development of transportation systems. In Vital Speeches (March 15 and June 15, 1977), there are two articles that discuss policies and management programs for transportation. These focus on water management programs, new policies for navigation--particularly heavy taxation--and their possible consequences for water supply, irrigation, reclamation, flood control, and other aspects of a multiple purpose water management program. Also, the articles address the relationships between different transportation modes (railroads, barges, planes), taxation, business interests, and economic growth.

Scientific American (January 1977) discusses the consequences of automobile mileage and emission regulations for the auto and fuel industries. These kinds of considerations are also pursued in Vital Speeches (June 15, 1977 and February 1, 1978). These two speeches are from the business viewpoint. One focuses on energy and the economy, and the problems that industry faces with current licensing regulations for production facilities--particularly the pollution controls for coal conversion and the building standards and waste management controls for nuclear reactors. The other is based on the conflicts between the mining industry and governmental regulations that control mining and land use, particularly in Alaska.

Other periodicals also explore the land use controversies in relation to regulation and control. An article in the National Review (June 24, 1977) further explores conflicts centered around the use and/or misuse of Alaska's resources. It describes how various interest groups are either fighting for or against different regulations of land use and water control measures. In Esquire (February 1977), this type of control is discussed in relation to the nation's rivers with respect to the effects of control on commercial and professional river outfitters and guides, and on private recreational interests.

One approach to dealing with government standards and the enforcement of violations is examined in Fortune (April 1977). An article in this issue discusses the timber industry in the Pacific Northwest, and how Weyerhauser Company exemplifies the views of many large timber companies as they work with government on timber management, land use, and environmental impact regulation.

LIMITS TO THE MANAGEMENT OF LARGE, COMPLEX SYSTEMS

(Social, Political, and Economic)

Before the United States reaches any physical limits to growth, we may face limits to institutional growth. There is growing evidence that we have combined small, accessible systems into large systems that are difficult to comprehend or manage, particularly in a democratic, participatory manner. Many of our major social, political, and economic systems, because of their rapid and complex growth patterns, are beginning to exhibit similar negative characteristics. These include:

- declining ability for participants in the system to understand it, or to see its deterioration, even with expert counsel;
- disproportionately rising costs to coordinate and control the system;
- decline in system resilience and increase in rigidity (e.g., the "paperwork" syndrome);
- increased system vulnerability; and
- lessening diversity in innovation.

The consequence of these problems may contribute to such social problems as the following:

- less citizen participation in decision-making;
- less public access to managers or decision-makers in the system;
- increased alienation;
- questioning of basic values;
- decline in the legitimacy of leaders; and
- increased unexpected consequences of policy decisions and actions.

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Examples of the problems of systems management can be found at any community level--local, regional, national, and global (e.g., economic problems of New York City, or the state of the national welfare system). For instance, it has been noted that the U.S. Congress has many difficulties in making technical decisions. Often one decision will require years of assessment and thousands of pages of testimony. A recent voter action in California, Proposition 13, became a catalyst that shifted the property tax base away from local governments, and caused pressures to allocate State funds to cover the losses. The ensuing activities as State government examined priorities and tried to pass the budget exemplified this complexity at the State level. A problem with our institutions is that they can become too large to even control themselves, let alone to control the external institutions for which they are created. A symptom of this problem is the failure to implement problem-solving goals set forth by new agencies.

Most of the current responses to these types of problems tend to adopt the "technical fix" solution, which attacks problems in a segregated fashion and depends on technological breakthrough. Other responses could range from authoritarian organization to a chaos with no one prominent form of solution. It is important to realize that interdependence of social, political, and economic systems. The difficulties in one often lead to difficulties for another.

The important aspect of this issue, the management of large, complex systems, is that it is concerned with a process--the process of growth and decay--rather than with tangible materials, and therefore it may not be as easy to understand as some other issues.

Responding to the more tangible symptoms of problems of complex systems cannot reach the underlying root or origin of the issue. Because responses or solutions to the complexity of a system are vital to the future of the system, care must be taken in selecting strategies that will not undermine desirable outcomes. The problems of complexity call for innovative and diverse approaches.

There are few articles in periodicals that really get to the basis of this issue. Rather, journalistic examples are of a more immediate concern, as a reaction to the runaway growth and problems of complex system management. These articles tend to assess symptoms and to prescribe solutions, some of a more innovative or long-term nature than others.

A few journals carry articles that discuss the growth and management of different energy systems. In the May 1977 issue of The Progressive, there is a comprehensive discussion about "public power"--the history of and current shift to the decentralization and cooperative ownership of utilities. In the November 1977 issue of the same periodical, an article explores the interdependence of large energy systems. With the example of the New York City blackouts of 1965 and 1977, this article examines measures that could ensure that large-scale blackouts would not occur again. An article in Scientific American (July 1977) also treats the issue of "load management" by electric utilities.

Another aspect of systems management concerns the problems of urban and rural planning. Vital Speeches (January 15, 1977) contains an example of urban management issues. This discussion examines the role of city management in setting policies and compares our current approaches with some European models. The conflicts between interest groups and government agencies, and the problems of interagency efficiency are also part of this issue. The problems of trying to save urban areas for public use, and the success of some urban planning in terms of parks management is discussed in the Smithsonian (November 1977).

Finally, the importance of land and water planning for food production is an example of global systems management. This aspect is discussed in relation to the use of natural systems principles and phenomena (the "free work of nature") in Scientific American (May 1977).

GROWING NEED FOR "APPROPRIATE TECHNOLOGY"

Currently, we are becoming more aware of the post-industrial nature of our civilization. As we confront apparent limits to growth--whether stimulated by energetic, economic, or political forces--we may have to simplify our level and patterns of individual and aggregate production and consumption. We are currently in the midst of a developing array of "appropriate" or "intermediate" technologies, emerging out of a growing need to provide practical support for these lifestyle changes. In order to create successful adaptive patterns, tools and techniques must become more "appropriate"--that is, they must become more evenly matched to available energy resources, and lifestyle or end use needs.

The major characteristics of an "appropriate technology" have implications for environmental impact, energy production and use, economic balance, and social, political, and legal structures.

The characteristics of an appropriate technology include the following:

- does not release pollutants of poisons into the environment;
- protects the existing natural habitat and the viability of existing ecosystems (e.g., biological pest control);
- recycles organic nutrients and protects or creates topsoil (e.g., composting toilets or vermiculture);
- conserves non-renewable resources and promotes the use of renewable resources (e.g., solar power and wind power);
- promotes the use of recycled materials (such as returnable bottles);
- reduces transportation dependence;
- promotes small-scale production, local ownership;
- promotes meaningful work and income, and is labor and skill intensive;
- promotes social flexibility, diversity, self-reliance, community cooperation and community control;
- is comprehensible and usable at the community level;
- enriches the human habitat and creates and maintains natural beauty.

The notion of "intermediate technologies" is one way to view the implementation of appropriate technology. These intermediate technologies are sophisticated and elegant, yet are consistent with the characteristics of appropriate technologies as outlined above. It is pointless to abandon our accumulated knowledge and technical abilities when they can make possible technogical self-reliance. This can be accomplished by instructing individuals and communities in the production and control of their own goods, services, and energy. This concept is most succinctly exemplified by the "small is beautiful" attitude proposed by E.F. Schumacher.[4]

Failure to encourage in an appropriate manner the development of intermediate technologies and their supportive social structures will make it more difficult to solve the practical and immediate problem of finding new ways to a healthy life in a world of increasing material scarcity. Failure to develop appropriate technologies would also result in missing the opportunity to creatively approach the social and technical aspects of the current transitional period.

Although many popular sources approach certain aspects of this issue, most seem to be examples of symptoms of the problem, rather than comprehensive discussions of the energetic, economic, environmental, and social effects of "appropriate technology." For example, the summer of 1977 produced two reactions to the Schumacher notion of "small is beautiful." The Harper's (August 1977) article relates to the National Energy Plan, while the Progressive (September 1977) article is a more direct critique of Schumacher's philosophy.

In Vital Speeches (July 1, 1977), the emerging conservation ethic, economics, and new technologies are discussed in relation to the National Energy Plan and its implications for consumer lifestyles, household energy expenditures, and leisure. The importance of available information for informed consumer decision-making about the technologies associated with products, their safety, and energy consumptiveness, is examined in Scientific American (December 1977).

A vital aspect of appropriate technologies--their relationship to the health of the community--is often ignored in popular literature. Journals tend rather to treat the negative aspects of a "non-appropriate" technology. For example, the devastating effects of the now functional Alaskan pipeline on the Eskimo culture, social attitudes, economic base, and energy use, are addressed in Harper's (September 1977).

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[4] E.F. Schumacher, Small is Beautiful: Economics as if People Mattered (New York: Harper & Row, 1973).

In the industrial and residential sectors, technologies are beginning to be discussed in terms of possible measures for conservation in buildings and production facilities. For example, articles in Fortune (May 1977) and Harvard Business Review (March-April 1978), both address the economic importance and opportunities of conservation and energy-efficiency strategies for industry to 1985. Also, Scientific American (April 1977) explains some conservation and cogeneration measures suggested by the Energy Research and Development Administration (ERDA) for both industry and the home.

The issue of solid waste management in terms of recycling seems to receive minimal attention in popular literature. One article, in Vital Speeches (July 1, 1977), discusses some aspects of recycling bottles and the recovery of solid waste from aluminum cans (from an industry viewpoint). The use of vermiculture (worm growing) to promote recycling of ground biomass garbage into high-yield fertilizer is explored in Nation's Business (January 1977).

In summary, then, the concept of appropriate technology seems to be covered in most sources mainly in a fragmented fashion. These discussions are generally concerned with contributing factors to a successful appropriate technology strategy.

SOCIETAL CHANGES REQUIRED TO ADAPT TO NEW ENERGY SOURCES

The aspects of this issue become more evident as knowledge increases about the energetic considerations of providing materials, food, and energy for the earth's populations. Even though new sources of energy and advanced technologies may produce abundant and economically cheap energy, the forms in which the energy is available may be quite different from those provided by fossil fuels. When diminishing fossil fuel supplies have become prohibitive in cost, we may find ourselves with a system whose structure and behavior are not feasible for these new energy forms and delivery systems (the means by which we obtain, process, and distribute energy for use).

If necessary changes in structures and patterns could be anticipated, it would facilitate more effective long-term investments and also prevent undesirable environmental, economic, and social consequences involved in energy futures. For instance, the multitude of changes required to shift from centralized to decentralized control of energy production and distribution should be projected in any policy statement. On a societal level, then, it is necessary to foresee the necessity for certain systems to alter and adapt, and to respond with a comprehensive and flexible policy for the implementation of energy strategies.

In an attempt to deal with the aspects of this issue on a national scale, a National Energy Plan has been introduced (President Carter: April 1977 and November 1977). This Plan has long-term consequences and implications for the ways in which the U.S. population adapts to energy resources. This adjustment is implied for the manner in which energy resources are obtained, who is responsible for their processing and use, and who bears the economic and environmental costs.

Evidence of the diverse opinions about the widespread effects of energy policy is found in the variety of reactions generated from different sectors of society and printed in various national publications. Vital Speeches (December 1, 1977) carried a transcript of the "President's Address on Energy Problems." The same issue carried one response to the Plan from the American Petroleum Institute, which outlines the oil industries' major objections. An earlier issue (June 15, 1977) carries a Senator's speech about energy resources and economics in relation to the proposed National Plan. A lengthy critique of the Energy Plan and the previous Ford Foundation Energy Policy Study (see A Time to Choose: The Report of the Energy Policy Project of the Ford Foundation) appears in Harper's (August 1977). The critique emphasizes the need to examine exactly what the consequences would be of various proposed energy strategies.

The major focus of an entire issue of Nation's Business (April 1977) is the National Energy Plan. Articles cover the reactions and proposals of the Chamber of Commerce of the United States, utility and energy industry representatives, the Energy Research and Development Administration, and the findings of a questionnaire submitted to a cross section of top business officials across the country.

In addition to reactions to the policy per se, the National Energy Plan statement also sparked many analyses of the current and possible future delivery and use of specific resources. Vital Speeches (October 15, 1977), and Scientific American (January 1978) both present discussions on the environmental nature and economic effects of increased coal technologies. The Progressive (April 1977), Nation's Business (also April 1977), and the August 1977 issue of Fortune all offer opinions on the availability, supply, and effects of the deregulation of natural gas. Fortune (October 1977) also carries an analysis of the future of liquid fuels on a worldwide basis, and discusses the necessary changes involved in a transition to unconventional liquid fuel sources. Scientific American (January 1978) discusses the U.S. hydro potential in terms of small, localized and locally controlled power stations. Finally, Vital Speeches (January 1, 1978) carries a comprehensive discussion of the implementation of the solar energy component in the National Energy Plan, as projected to the year 2000. This discussion includes economics, labor and employment opportunities, and the various technologies that comprise direct and indirect solar conversion strategies.

From reviewing these examples, it seems apparent that the societal changes needed to adapt to new energy sources will be challenged to a great degree by the energy industries, and more easily accepted by smaller, local agencies. It is necessary for all segments of the population to be exposed to these controversies in order to help create the required atmosphere for a successful transition to new energy systems.

OTHER ISSUES OF NATIONAL PRIORITY

We have given an overview of six critical national priority issues, and the way in which they are currently presented to the public by some national publications. However, as we indicated earlier in this section, there are some other pre-critical national issues that do not seem to be either of current widespread interest or are not examined frequently in recent national journals. A brief discussion of these national issues follows.

Impacts of Technology on the Individual Psyche

It is possible that constant exposure to the tools and devices of technology could have a serious effect on the human psychological structure. Due to the subjective nature of human experience, few investigations have gone past assumptions and theories about these effects into the realm of observation or measurement. We know quite a bit about some of the physical impacts of technology, such as the health and safety factors associated with pollutants. However, we have less quantitative knowledge about the social impacts, such as the automobile and freeway and their relationship to urban sprawl and the dissolution of the inner city.

The technologies of our culture are capable of producing very focused and intense sensations. These include stereo, color television and motion pictures, and mind-altering substances. It is possible that the individual may become somewhat "addicted" to these high levels of sensation, requiring even more stimulus to cross the threshold of significant nervous impact. For others, the result may be a loss of the capacity to cope with stimulation "overload" and the blurring of the distinctions between the real and the unreal.

Overall, the most fundamental aspects of our experience are our relationships with space and time. The technological advances in the last century have changed our interactions with the world to include a greater amount of space and time with a technological environment, rather than with a natural one. The feedback of that technological environment on people themselves could cause unanticipated problems in our values and attitudes, including those relating to where you are, where you want to go, how you are able to go, and how you get there. The effects on the individual may be rootlessness, or a lack of sense of home.

Effects of Stress on Individuals and Society

Millions of Americans are affected by the consequences of stress daily. Direct effects could be as slight as lack of sleep or a backache; or the effects could be as serious as death from heart attacks, accidents, or suicide. Indirect effects, such as alcoholism, mental illness, and poor performance of job tasks are estimated to cost the nation more than $100 billion per year.[5] We have a fairly complete picture of the medical treatment for stress symptoms. However, unless we can understand the various types of stress and their diverse impacts, some forms of treatment may actually cause stress reactions to worsen. It is useful to know, for example, that in one sense stress can be viewed as beneficial for growing organisms, for it can produce the impetus for growth.

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[5] Center for Study of Social Policy, Assessment of Problem Areas, February 1977, p. 46.

Stress has been widely researched in the years since World War II. However, relatively little of this research addresses the aspects outside the conventional medical perspective. These dimensions include roles, causes, uses, and "alternative" treatments to drug therapies such as meditation, biofeedback, or self-hypnosis. It is necessary to understand the social dimensions of stress problems, as well as the medical ones, and that diagnosis and/or treatment at both of these levels are vital.

In modern societies, stress seems to be increasingly a product of interaction with the technological or human-generated environment, rather than with the natural physical environment. Psychological responses to stress are at least as important as the physical effects. This change in emphasis can be attributed to such factors as larger, more complex concentrations of population, mass communications, and loss of direct control over aspects of one's own life.

The rates of change of a technologically advanced society are also suggested to have a great deal to do with stress and its related symptoms. Rather than the pace of change slowing down, technological and social changes seem to be proceeding at an even faster rate. From this, we can probably expect even higher levels of stress-related behavior.

Advances in Biomedical Technology

Most of our population has little or no direct contact with major developments in the biomedical sciences. However, there are instances when even the furthest removed are affected by new technologies, for example, when new pharmaceuticals are purchased, or when one is helped by a new device in an emergency situation. Most new technologies fall under three major categories: (1) those that offer extension to life; (2) those that are involved with genetic engineering; and (3) those that involve the aged and unfit.

The development of life extension methods seems to raise questions about access, in terms of economics as well as in terms of supply and demand. Experience thus far has suggested that the supply of surgeons and natural organ transplants or synthetic replacements will probably not meet the demand.

The developments of genetic engineering create new and untested problems in both social, ethical, and moral contexts. An important example is the successful fertilization of a human ovum outside the womb in summer, 1978, which spawned the realization that it is possible in the near future to control not only the sex and physical, mental, and emotional make-up of human beings, but also to whom they are born. These techniques are modeled after those developed in animal husbandry.

Finally, there are strong movements developing that promote the concept of euthanasia--voluntary death for those lacking a place or who are too ill to continue as a functioning member in society.

Growing Conflict Between Central Control and Individual Freedom

Scientific advances have produced technologies with incredible power, scale, and sophistication. The growth of large and concentrated urban complexes and equally large and sprawling metropolitan regions contributes to the decline of social cohesion and human-scale institutions, such as the family and the community. High crime, economic ills, and energy problems are some of the major concerns that seem to be demanding immediate and effective consideration and solution.

Because of the enormous power and possibilities of our technologies, we have deemed it necessary to create equally powerful regulation. The scale of the organizations needed to manage this regulation makes them more and more remote from and dominant over the citizenry, rather than immediately responsive to it. The decline of social cohesion places a greater burden on these formal institutions, and sometimes the urgency of problems seems to demand that individuals sacrifice freedoms and often civil liberties. These are often quite willing sacrifices, usually "crisis-bound," such as the warrantless search of persons and personal belongings at airports, where the threat of highjackings exists.

The overall result of these factors seems to be a reduction in the accountability of large institutions, in the effectiveness of individual choices, and in the preservation of civil liberties.

The Potential Use and Misuse of Consciousness Technologies

"Consciousness technologies" are an applied interdisciplinary science that takes relevant aspects from medicine, physics, psychology, neurophysiology, and parapsychology. Potential impacts of these technologies--both for good and ill--are only now becoming evident. They can present either an important opportunity or a considerable problem, depending on their availability and application.

For example, there is an increasing body of research that indicates many diseases are psychosomatic--they involve mind-body interaction. It is possible that integrating the mind-body component into treatment could be a powerful aid in reducing disease. Also, consciousness research indicates that the human potential for learning, creativity, healing, and other mind-centered activities far exceeds our current assumptions. It is possible that there are sociocultural and/or professional barriers restricting the application of new techniques for problem-solving in such fields as health care, education, and criminal rehabilitation.

It has become obvious that psychic abilities do exist. There is, however, the potential for their misuse in two major categories: (1) in the acquisition of confidential information; and (2) in the possibility of the generation of long-term effects that could be physically or psychologically debilitating. These technologies could be rapidly developed, with current scientific investigations.

Chronic Unemployment

The possibility of chronic unemployment is an actuality. Due to many changes in the economic situation, such as environmental and other constraints on economic growth, this issue may become more evident in the public awareness. There are various indications that a high degree of hidden unemployment exists at the present time, and it is probable that there will be more in the future. It is possible that without an accurate identification of the long-range nature of unemployment, there would be expensive attempts to correct the situation with symptomatic rather than preventive measures.

The Sociocultural Effect of Mass Media

An increasing amount of people's experiences are through vicarious media, rather than through direct interaction with the world. As a result, their social reality may be somewhat distorted, and their judgment may be increasingly susceptible to intentional and unintentional manipulation. This indirect contact with real world situations may also result in withdrawal from direct political and social participation.

The media structure the world for us, and perform an "agenda setting" function, by directing our attention toward some things and, by not treating them, directing our attention away from others. It has been indicated that media emphasis on an event is associated with the audience perceiving the event as important. For example, there is evidence that extensive television viewing would result in a higher misperception of the crime rate. These considerations--the role of mass media in shaping public perceptions and attitudes, and the effects of media on the public and the nation's priorities--seem to be of increasing interest to many sectors of the society, and there is a growing bank of literature on this subject.

Inefficiencies in Problem-Solving Caused by Institutional Boundaries

The scope, scale, and concentration of human activities has increased, and will continue to increase at a rapid rate. To cope with this increase, we have designed and interconnected an increasing number of societal institutions. Although highly interrelated, these institutions are not highly coordinated. This is unfortunate, for they have become important for the resolution of national and international problems.

The number of professional associations and political influence groups, as well as distinct and functional disciplines of great influence, have increased considerably. We have seen the emergence of multinational corporations, many of which have budgets larger than their countries of business. The institutional boundaries created for a less tightly woven society tend to compartmentalize problems and tend to prevent comprehensive treatment of problems of a systemic nature. These problems require effective coordination of problem-solving efforts that cross organizational boundaries. This is difficult with the multitude of governmental, nongovernmental, and semi-governmental institutions at all levels--local, regional, national, or global.

Loss of Political and Social Cohesion

There seems to be a change in social cohesion, which is the sense of purpose that provides the balance between individual needs and desires and the social well-being. It is the ability to agree on goals, priorities, and courses of action that provides this cohesion. The lack of this agreement can be disruptive to family, business, and government structure and functions. One example is the nature of many activist groups, and the resulting advocacy system in which compromise is practically impossible. Another example is the effects on the nuclear family of changing career attitudes about age and sex.

Another aspect of this loss of cohesion is seen in the effects of a "mass society" on social organization. An example of such a social system is a large city where millions of people are tightly linked to an even larger system than the community or city itself. As we make the transition to a post industrial society, it becomes evident that our current mass society interweavings of association seem to be exhausting their potentials for cohesiveness. As a result, people tend to fall back on less complex life systems, which are less extensive and more comprehensible.

With smaller life systems, it is possible to lose social cohesion for the larger society, but to increase cohesion for the individual. Accordingly, it may be that the dynamic point of balance for social systems will be the point where social cohesion is strong enough to make social evolution democratic, yet is not so strong that it rigidifies the culture into nonevolution.

Potential Conflict Between Low Growth and High Expectations

Historically, both in the United States and around the world, the reduction of poverty has been dependent on high rates of economic and industrial growth. If expected or needed growth does not occur, there could be drastic effects for those at the bottom of the economic ladder. The consequences for the poor would be felt even by those who are better situated. This problem is worsened by the fact that, even though the bottom of the ladder is not as close to the ground as it was a century ago, the gap between the rich and poor nations in per capita output has grown by a factor of ten.[6]

If the world is facing fundamental limits to growth, or if some nations will not be able to achieve their expected or needed growth due to a potentially unmanageable economic system, then this will widen the gaps both within nations and internationally, and could increase the potential for political instability and violence.

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[6] M. Messarovic and E. Pestel. Mankind at the Turning Point-The Second Report to the Club of Rome (New York: E.P. Dutton and Co., Inc., 1974.

The Social Response to Energy Disappointments

As we have seen in some previous discussions, there are already delays and uncertainties in obtaining new energy sources. It is probable that this trend will continue into the near future. Until the transition technologies are in place, investment uncertainties most likely will discourage private investors from depending on older technologies for economic gain.

There may be strong pressures exerted for the control of the consumption of resources through the implementation of rationing. Other measures may include the nationalization of utilities and the coal, petroleum, and gas industries. The resulting delays and conflicts could have a variety of societal effects.

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CONTENT
COMPONENTS

When examining as broad a concept as Environmental Education, it is important to understand the significance of our modes of inquiry as well as to examine their limits. In each of the natural and social sciences, we are given a specific set of tools that provide us with a valuable means for explaining and understanding certain phenomena. Through generally deductive modes, we arrive at a kind of model of "reality" within a universe that demands broader modes of explanation. We often find our explanations falling short, and therefore we resort to generalizing about the nature of things and of human beings. In other words, we tend to induce distortion automatically as we focus too tightly on one explanation. This "distortion" of the world is not in and of itself necessarily undesirable.

Problems arise as we view one disciplinary explanation exclusively as the only mode of analyzing what is "out there." So, in understanding the world, we are constantly challenged to expand our perceptual maps into wider and wider spheres of ambiguity.

Ideally, Environmental Education is transdisciplinary. At the heart of the ecological perspective is the realization that human/environmental systems cannot be comprehended by studying their isolated fragments.

> Subduing and subdividing it into easily manageable units only destroys its most important features, the processes of interaction which make it attractive and functional. Rather than simplifying our subject matter, we must learn to complexify our means for comprehending it. Genuine environmental scholarship will have to emphasize the understanding of processes above the measurement of entities. Environmental Studies should be structured as ecosystems are, recognizing complex interdependencies

> and accepting competition, contradiction, and uncertainty as necessary conditions for learning. Their goal should be the encouragement of wisdom and good judgement, leaving the task of filling our information cribs to the academic [specialists].[1]

The traditional pursuit of knowledge via academic disciplines is useful only insofar as one locates its parameters within a much greater whole. Organism and environment are mutually co-defined systems; neither is whole without the other. Yet an organism is isolated from its environment for purposes of study. A temporary discrimination is made, enabling the disciplinary eye to focus upon its object of interest while the investigator hopefully remains aware that it cannot be totally removed from its environmental context.

In order to become manifest, "content" demands "form" for its proper expression. This "form" must be looked at within a context. As Bateson says, "It's the context that fixes meaning."[2] The Content Components presented on the following pages are oriented toward providing the learner with an integrative mode of inquiry by allowing investigation of "form" and "context" as a whole.

The Content Components are listed below and described at length in this section.

1. SYSTEMS APPROACH
2. PROBLEM-SOLVING AND DECISION-MAKING
3. ENERGY/ENVIRONMENTAL CAREER RELATED DECISIONS
4. HOLISTIC LIFESTYLE ASSESSMENT

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[1] Joseph W. Meeker, "Academic Fields and Other Polluted Environments," The Journal of Environmental Education, 4:3 (Spring 1973), page 38.

[2] Gregory Bateson, "The Pattern Which Connects," CoEvolution Quarterly, No. 18 (Summer 1978), page 12.

5. IDEAL ENVIRONMENTAL WORLDVIEWS
6. FUNDAMENTAL CONCEPTS OF ENERGY
7. ENERGY/RESOURCE DELIVERY SYSTEMS
8. FORECASTING, PLANNING, AND POLICY FORMATION
9. FUTURES THINKING

SYSTEMS
APPROACH

A. INTRODUCTION: THE SYSTEMS PERSPECTIVE[1]

Social and technological changes occur at a more rapid pace today than at any previous time. As Sir Charles P. Snow (1969) remarked, "During all human history until this century, the rate of social change has been very slow. So slow, that it could pass unnoticed in one person's lifetime. That is no longer so. The rate of change has increased so much that our imagination can't keep up." This accelerating rate of change--and the accompanying increase in the complexity of the systems that surround us--has brought us to a threshold beyond which we face the possible loss of control of society's direction (Vickers, 1963).

Experience no longer seems to be an effective teacher. Trial and error requires more time than is now available for response. Commenting on our inability to solve social problems, Schon (1971) observed, "It seems that the time required to move from diagnosis to the design of solution, implementation, and extension to the next instance, is long enough...to include changes which invalidate conclusions once they are reached."

What these observations seem to tell us is that the rate of change and the complexity of man's systems have increased to the point where we are unable to adapt to this change by means of our customary ways of thinking. There is an urgent need to change our ways of dealing with problems and to increase our ability to learn and adapt. Success in problem-solving requires finding the right solution to the right problem. Today we often address the wrong problem:

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[1] Adapted from Bela H. Banathy, et al., "The Design of a Macro-Societal Model of Education and Human Development," (San Francisco, CA: Far West Laboratory for Educational Research and Development, 1978).

> The problems we select for solution and the way we formulate them depends more on our philosophy and world view than on our science and technology. How we go about solving our problems obviously depends on our science and technology, but our ability to use them effectively also depends on our philosophy and world view. These, in turn, depend on the concepts and ideas we use and how we use them to organize our perceptions of the world. Fundamental changes in these organizing concepts and ideas and the way they are used move societies from one age to another.
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> [Ackoff, 1974]

We are now at an early stage of changing our way of thinking, and consequently, of changing our methods of addressing problems. We are moving from the age of reductionism and analytic thinking to the new age of expansionism and a synthetic or systemic mode of thinking.

Reductionists seek to break down wholes into their components and to understand the whole in terms of its parts. Through the process of analysis a complex problem is decomposed into parts suitable for analysis by specific disciplines. Once the analyses of the parts have been completed, the parts are assembled into a solution of the whole. Interaction between objects, events, and their properties is further reduced to cause and effect. As a rule, the analysis of a cause-and-effect relationship is accomplished in laboratory settings where environmental effects are excluded. Effects are determined by causes; thus the worldview of a reductionist is deterministic.

Having been faced with increasingly more complex technological and social problems, we have learned to realize that we can no longer find solutions with the thinking and tools of analytically-oriented disciplines. Thus, of necessity, we have had to evolve a new way of thinking and a new approach to disciplined inquiry.

The doctrine of reductionism and the analytic, cause-and-effect mode of thinking are now being supplemented and partly replaced by the doctrines of expansionism, a synthetic (systems) mode of thought, and a holistic, interdependent view of the world.

Expansionism is a doctrine that maintains that all objects, events, and experiences are parts of larger wholes. It does not deny that wholes have parts, but it focuses on the wholes. It turns attention from atomic elements to systems or wholes with interrelated parts. Expansionism generated the systems model of thinking the same way the analytic mode of thought was brought about by reductionism (Ackoff, 1974).

The concept of systems was developed most comprehensively by Bertalanffy (1968), who saw this concept as a wedge that could open science's reductionistic and mechanistic view of the world so that it could deal more effectively with problems of living nature and with biological, behavioral, and social phenomena for which the application of physical science is not sufficient and, in some cases, not even possible. The concept of "system" has since played an increasingly larger role in organizing both our lay and scientific view of the world. The concept is not new but its organizing role is.

The synthetic or systems mode of thinking has led us to reconceptualize science as a complex whose parts--the disciplines--are interdependent. The various related disciplines are assembled in subsets and the various subsets form an even larger entity: systems science (Ackoff, 1974).

Systems science has demonstrated its capability of effectively attacking highly complex and large-scale problems. It evolves models--constructed of systems concepts--which are applicable to more than one of the traditional fields of knowledge. Furthermore, it develops strategies that can be applied to the solution of problems. The integration of systems concepts leads to an acquisition of the systems view. The systems view enables us to take a new view of ourselves and our environment. This new way of thinking can be applied to the analysis and understanding of complex problems, such as problems related to the interaction of the systems of humans and nature.

B. THE LANGUAGE OF SYSTEMS THINKING

Discussing the problems and solutions of the humanity/environment nexus requires us to take a broad perspective of such a nexus. This approach, called a "systems perspective," was reviewed in the introduction to this section. To elaborate this perspective, a special language is required. The conceptual base of this language is systems science. It is not a highly technical language employing totally new symbols or syntax, but rather it contains metaphors, connectives, and phrases derived from biology, cybernetics, systems engineering, and social science. This language provides the user with a means of expressing a broader, more unified perspective with regard to the environment and the system appropriating the environment.

The introduction to systems language provides some analysis of the use of this special language, and provides the insight that a new mode of speaking creates a world-perspective. This means that systems language expresses underlying values, ideas, goals, and realities that cannot be readily expressed in ordinary language. A more elaborate explication of this is provided in the section entitled "The Usefulness of Systems Language."

Using a "new" language based on ideas and notions, perhaps only intuitively or partially expressed, has practical and theoretical consequences. In our case, systems language enables the user to connect hitherto apparently diverse processes, events, or entities into a "whole." This ability to connect found in the appropriate use of systems language is examined in the section entitled "The Consequences of the Use of Systems Language."

To some extent these consequences are examined from a somewhat different perspective in the section entitled "The Claims of Systems Language and Some Critical Remarks." In this section some recognition is made of the fact that any perspective necessarily contains problems about which the user needs to be aware.

The use of language, its consequences, claims, and limitations are presented here in essay form. However, these sections represent categories that can be easily expanded by further examination of the relevant literature in anthropology, linguistics, and philosophy of science, and general systems theory. Hence, one can construe this essay as a base outline for a discussion and critique of systems language.

1. The Usefulness of Systems Language

The bounds of our thinking are prescribed by the kinds of language we use. Mathematics provides physicists with a way of formulating problems and their solutions that is precise, replicable, and conceptually elegant. Language allows one to perceive events in a certain way as if through a set of lenses. This is the case because events, to be meaningful, require interpretation; that is, language conveying descriptions of an event needs to be related back to a referential system through which we can interpret what we hear or read. Such a referential system is constructed by perceptions, sensations, and images as these become part of memory and are shaped by the linguistic and cultural systems of the individual. The event-descriptions themselves are dependent on some underlying presuppositions.

To preclude self-fulfilling statements, the process of theory-building and hypothesis-testing requires replication of similar instances of events under different, controlled conditions. This form of scientific method has acquired a great reputation in the natural sciences. The social sciences, however, provide many instances in which the exactitude and parsimony of the natural sciences breaks down. Indeed, there is an important tradition dating back to Aristotle that argues that a language describing objects cannot be used to describe human beings and their institutions.

In ordinary life, the language we use determines our experiences, and our comprehension of them. New words are invented to enable one to see, or to explain novel arrangements of familiar experiences. Drinking wine does not seem to be a very complex experience, yet there are at least twelve categories (bouquet, acidity, essence, body, aroma, etc.) that describe nuances for which one may have to be trained to actually experience. In our social and cultural life, there are numerous experiences that can be expressed only by a very special language. Our relationships to other persons, to machines, to natural items are all heavy with linguistic expressions and structure, some unique, some ordinary. The poet may free language with metaphors that connect experiences which hitherto appear unrelated. We may thus be able to see ordinary items in a new, vivid way. A candle is surely a nondescript object, but when Macbeth says, "Out, out brief candle!" that object becomes tremendous, expressing a despair which given one interpretation, challenges the optimism of Christianity.

The same items, the same events can be related to one another in different ways given different presuppositions, values, scientific theories, or cultural structures. These differing interpretations are tested by noting how they function as explanations in analogous or somewhat disanalogous situations. When the interpretations break down, i.e., when they produce contradictory, or counterintuitive results, a crisis occurs that may require a new language. These results might be explained away by appeals to biased data, invalid implementation, inappropriate use of language, etc. However, when a large number of contradictions and "mistakes" persist, the theory or law that is presupposed as a basis for interpretation will require replacement. The classic example in science is the replacement of the Ptolemaic system by the Copernican system. In ordinary life, an example is provided by the belief that natural resources are unlimited. Thus, the ideas of social status attached to unneccessary consumption are being questioned. Transformation of thought, however, is not as quick or orderly in society or in culture as it appears to be in science. Even so, according to Thomas Kuhn's Structure of Scientific Revolutions, generations of scientists may have to die off before a "revolutionary" idea becomes an established scientific perspective.[2] However, scien-

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[2] Thomas S. Kuhn, The Structure of Scientific Revolutions (Chicago: University of Chicago Press, 1972). For readers familiar with this work, Kuhn's concept of paradigm may be substituted for "language" as it is used here. See Margaret Masterman's discussion, "The Nature of a Paradigm" in Imre Lakatos and Alan Musgrave, eds., Criticism and the Growth of Knowledge (Cambridge University Press, 1972).

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tific language is precise enough so that one scientist knows what another is referring to despite disagreements.

In the social sciences, such revolutions are not possible because of a total dissimilarity of languages used. The psychoanalyst and the behaviorist speak as though they are referring to radically different subjects. Moreover, they find each other almost incomprehensible. The lack of a common language, or even a means to consensus, precludes the possibility of a unified discipline in the social sciences. A further difficulty is that radical antinomies analogous to the behaviorism/psychoanalysis controversy exist throughout the social sciences. It is unclear whether more time is required for decisive research or whether the discovery of a new principle that may unify these opposed scientific paradigms would be fruitful.

Basic to living, it appears, is the economic structure of production/distribution/consumption. The specifics of each of these processes is determined by the decisions of large numbers of persons. Once again, contradictions emerge when attempts are made to assemble all of the determining factors that relate together to produce the necessities and luxuries of everyday life. Specifically, the natural resources upon which industry, jobs, money, and commodities are dependent are being destroyed by these dependent socioeconomic structures. Moreover, the aggregate choices made by class, status, social, and kinship groups are grounded in unconscious presuppositions that may not be expressed, let alone criticized. These presuppositions were formed largely at a period of history in which "nature" was considered an unbounded resource. If shortages of natural resources were suggested as possible, it was believed by both scientists and the public that technological cleverness would more than make up for any depletions.

It is clear today that these presuppositions are in a state of crisis. Newly mounting scarcities, due to socioeconomic decisions, require recognition of novel factors that will transform the decision-making process. Recognition includes the need for a language founded on coherent presuppositions to describe the crisis, and thereby to develop a clarity of perception and attitude regarding the problems of human society, human decision-makers, and the environment.

Such a language would provide the kind of expression necessary to relate those items that consume/distribute/produce to symbols, values, needs, and commodities required by persons within institutional, organizational, and cultural processes back as a whole to the natural sources of all these levels, processes, and groupings. To return to an earlier metaphor, the wine one drinks can no longer be merely drunk. We need to attend to color, aroma, the barrels in which it is fermented, and the amount of sun the grapes received in order to enrich and transform the value and meanings of our choices. To enable one to think clearly about society/person/environment, a new language must be acquired to allow one to perceive, experience, value, and conceptualize the relationships between people and the environment. Similarly, in scientific discourse, anomalies emerging from previously coherent and appropriate theories, rules for interpretation, and hypothesis-testing require not a new theory, but a new approach to theory-building as such. Essential to this new approach will be a new language or a novel use of language relative to the one previously used.

What kind of language is it that could deal with the humanity/environment dialectic? We have suggested here that the difficulties and contradictions surrounding the relations of everyday life, economic and social life, and the natural environment need to be examined as a single system of interrelated processes. Each process or system has its own cluster of scientific disciplines that describe, explain, and predict events or trends within that process. Moreover, those disciplines are further divided into different schools for theory-building and event interpretation. For eample, economics has classical, neoclassical, Marxist, and Keynesian schools. There are controversies between sciences over what counts as a fact: a follower of Freud simply would not recognize operant-conditioning as a reality, while an "empirical" description of an Oedipal complex sounds like an arbitrary construction to a Skinnerian. From another point of view, the data from these scientific sources may provide data for other scholars using still different languages: economics, anthropology, and sociology may support research carried out by historians. In turn, historians may maintain that these human sciences require historical research for a sound empirical basis. All of these diverse languages contribute to and use some of the basic factors involved in the way humans look at, explore, and appropriate the environment.

A language is required that can unify these diversities by seeking out analogies in the interactions between people and the environment.

A language that unifies the diverse languages of thought, action, and feeling into a unified, transdisciplinary view of reality would enable one to analyze events into sub-processes, and yet be able to grasp the interrelations between universal processes. This super (supra-) language has been a dream of thinkers ever since the babble of scientific thought began. Aristotle conceived of a science that has as its data all the sciences. This he called metaphysics. Hegel recognized that science, culture, and society were all based on human desire: the desire of consciousness to become whole. Hence, he conceived of human history as the endeavor to combine opposition into harmony. The logical positivists rejected this as mere speculation, but argued that all "true" science was founded on a single unified methodology for the empirical verification of propositions.

The language we are presenting here is uniquely founded. General systems theory (more accurately, the general theory of systems) is not based on any claims about the substance of the world; rather it is a theory about the ways in which entities in the world are adaptively and purposefully related to each other. It is a science of integration and synthesis, a science of complexities, of organized constraints and resources, of unified diversities. However, general systems theory is not a logical structure bereft of subject matter, as it does represent actualities and potentialities that can be observed and predicted. On the other hand, it is not a specialized empirical science that makes special claims about a selectively and uniquely defined class of facts relevant to a specific theory base. Rather, it provides a meta perspective (a Weltanschauung) by which points of analogy that cut across disciplines can be coherently described, examined, and synthesized into patterns.

For example, the U.S. government, the fermentation of wine, the operation of an automobile, or the human brain all require information, all transform that information, all waste some energy, all have some output, and all have some apparatus for keeping all these processes dynamically stable and goal-oriented. A balancing act is performed in all of these processes and evolutions between external demands and internal constraints. The U.S. government can change goals, meet new demands, and transform its environment by reorganizing itself within the framework of laws and public consent. Wine has been made under the same conditions, with the same goals, methods, and devices for hundreds of years to produce a Bordeaux of a Valpolicella. Once conditions have been stabilized, the required transformation is completely from within the biochemical structure of the grape juice and the fermenting agent. Automobiles can stop running due to the internal constraint of fuel. The automobile's ability to adapt is completely external.

Different hierarchies of analogies and similarities emerge as different descriptors of a system organize the various data in different ways. We might develop a hierarchy according to adaptability. The government is more adaptive than is the wine-making process which, in turn, is more adaptive than an automobile.

Other hierarchies can be developed using different descriptors. A general theory (and language) of these systems would provide precise alternative ways of speaking about all of these systems with respect to their normal functioning, their adaptive functioning, and their dysfunctioning and degeneration.

The value of such a language for the sciences is apparent. One can translate from one discipline to another; channels of valuable ideas and fruitful problems are made possible through this general lanquage. General systems theory provides us with more than a language with the potential for providing a unified worldview, however.[3] General systems theory is advantageous in that it can be used to unify science with the ebb and flow of everyday life. The erudite theories of science and philosophy can be made available for day-to-day personal decision-making through general systems theory.

We are providing a language that can deal with interaction by connection, through which the immediate simultaneous and future consequences of actions can be perceived. Today, the act of purchasing an automobile has consequences that are political, economic, ecological, social, and cultural. The practical and social need for a car created the need to design and produce a car. The decision to design and produce a car reaches deep into a mountain where ore is obtained; it will give hours of work to a large group of automobile workers and motor vehicle division bureaucrats; it creates more pollution from steel mills; and so forth.

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[3] Examples of alternative approaches to unifying the sciences can be found in Nagel's Structure of Science, Popper's Logic of Discovery, Kuhn's Structure of Scientific Revolutions, Hempel's Aspects of Scientific Explanation, Whitehead's Process and Reality, as well as the work being carried out in phenomenological research.

The economic dependencies of all the persons involved in this process require the manipulation of the consumer's decisions to continue to need a car at profitable intervals. That car will create further demand on petroleum resources, and the demand for a petroleum industry, and will produce pollution that will damage many facets of the natural environment. The existence of that generic car means that the future quality of life, and the organizational structures in which people live and work, the aesthetics and the joys of nature, as well as the objective value of natural habitats will have been depleted, if not undermined.

To a specific degree, responsibilities for a single decision become complex and too staggering to express and conceive in ordinary language. General systems theory can unite these complexities by picturing them in these various levels and adaptations through time. The pictures created are not visual aids, but are symbolic or iconic representations of a reality disguised or obscured by the limited ordinary discourse available to most of us.

In medieval art, a whole moral or theological interrelationship could be inscribed within a single, timeless cluster of figures, spatial relations, and symbols. In such an icon, an act (sinning), and its consequence (eternal damnation) could occur in one image. The perceiver understands this relation in one meaning-rich glance. Time, individual nuance, and intervening variables are eliminated to present a clear, unambiguous statement.

In systems language, icons are more complex, but they provide a similar unified expression. A mountain, ore-mining, designing a car, managing production, producing, selling and buying a car is one thread crossing many more threads that can provide the viewer with a many-dimensional tapestry of events/decisions/consequences. The nature of the interrelations between these threads can show logical, causal, legal, symbolic, organizational, or informational flows and interactions from a given decision and action taken. Reading and understanding these relationships can be provided by understanding the symbolic notation and syntax of a systems icon.

Of course, many systems ideas can/are expressed in ordinary language and mathematics. One can describe the extinction of a species of bird or insect verbally. But to see the steady collapse of an entire network of relations and other species can provide remarkable insight into the complexities between human labor, thought, and the environment.

2. The Consequences of the Use of Systems Language

The adoption of this language and its use in mediation between events involves a reorganization of one's mental and emotional setting. It is one thing to see a system and another to interpret one's life, job, society, government, and world as a system. Even more is involved with understanding one's future as a further development of that same system. This understanding is basic to the rational designing of one's future with reference to the continuing development of the systems-language user's awareness of his or her relation to the environment.

Clearly, a distinction can be drawn between someone using systems language to express a model or icon when one explores a system, and one who designs a prescriptive model for a system that is desired or deemed necessary for the future. This describes the general difference between a passive observer and an active designer. The former is satisfied with the acute description of a process for achieving a goal; the latter is interested in generating goals and means as a goal-directed individual.

In our case, this design process includes the natural environment as a focused, purposeful reorganization of one's worldview. The environment, from the microscopic to the universal, from mineral to animal, would include the designer not only as a specific person, but also as a human being. This is the case because systems language assumes that every decision made reflects not only practical concerns but also the humanity, or universality, of the designer. When the language provided here is used, therefore, it brings all of the ecological, political, social, and cultural together in a single expression or icon, making its use universal.

Furthermore, this icon presents enough recognizable detail, enough concrete elements so that the reflection/self-organization/

future design process is neither mysterious nor arbitrary. The existing interrelationships between pollution, resource depletion, economic crisis, and short-range, piecemeal thinking can be clearly described and explained. The concerned observer uses the tools of systems language to integrate the data in that interrelationship, and can concretely assemble the necessary resources to envision a different, but practical, new arrangement.

The language of systems allows one to think/imagine about the interconnections between the components described here in alternate ways. No new events or facts are being introduced. Nor does this language require complex causal laws to connect classes of descriptive data. Relations may be described causally or metaphorically; nevertheless, the relationships described actually exist on some level.

Systems language provides a ticket to make inferences of varying degrees of strength. This ticket permits the mind to range from an event in its own immediate environment to an event in a distant place. While writing on this piece of paper, one is aware of the cutting of trees and the pollution of streams by paper mills. The writer's complicity is an imaginative leap that clearly may be reconstructed as a causal chain when further data is acquired. One may see metaphors, images, and undefined ideas which, utilized imaginatively, could enable one to envision a future in which one's complicity in polluting the environment is ameliorated.

In summary, given systems language, the intellect and the imagination are thereby given a disciplined freedom. Moreover, the flexible syntax of this language allows for an imaginative restructuring or wholly new design for one's life, or for the life of a nation.

3. The Claims of Systems Language and Some Critical Remarks

What is the explanatory/descriptive power of general systems language? There are two claims for systems language. One is that human experience of this particular moment, or of a lifetime, is describable in terms of systems. That is, it is plausible to believe that institutions and actions are purposeful, and the success of the actions directed to that purpose are assessed by the contrast/comparison of actual outputs to expected outputs. Moreover, there is an observable (measureable) stability based on the quality of information admitted to the system. This observable stability is balanced by a necessary instability which allows a system to adapt to (and to be adapted by) surrounding environments.

The second claim is that the information about the world given in the first claim can be basic to purposefully designing the future operations of most human systems (culture, society, the state). One can locate the levers and pulleys of one's individual or universal situation and control them by various means to attain an imaginable, desired situation.

These two claims are based on a third claim, which is that these systems can be accurately expressed in models that use the language we are presenting here. We can explore the descriptive and prescriptive claims for systems language by discussing the relation of a model to an existing or future system.

Models in science are used to interpret postulates that define the basic terms of a theory. A model interprets the premises of a theory in terms of some analogous, familiar subject matter. Analogy is basic to model-building and the interpretation of theories (premises of explanation), which are either true or false. Nagel suggests two broad classifications of analogy: (1) "a system of elements possessing certain already familiar properties, assumed to be related in known ways as stated in a set of laws for the system, is taken as a model for the construction of a theory for some second system" and, (2) a formal, or structural type of analogy which is "the system that serves as the model for constructing a theory in some familiar structure of abstract relations..."[4]

An example of the first type of analogy would be to construct a city (in relation to a natural environment) as a biological organism, or, to perceive the process of self-organization and design as analogous to riding a bicycle over a variety of terrains. The second type of analogy is more technical. An example might be water flowing through a pipe as an analogy of electricity flowing through a wire.[5] Another, more relevant example would be to model the formal elements of the flow of energy resources through a city as a hydraulic system.

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[4] Ernest Nagel, The Structure of Science: Problems in the Logic of Scientific Explanation (New York: Harcourt, Brace and World, 1961), p. 110.

[5] The equation governing the flow of water in a pipe is $V = \frac{C}{L}(P_1 - P_2)$; $I = \frac{K}{L}(V_1 - V_2)$.

Models can be used to explore the consequences of theoretical or practical assumptions, or to explain or expand the scope of the valid application of experimental laws. One can routinely reformulate models to gain different perspectives on a decision or action. (For example, interesting results may be obtained if the Alaskan pipeline is modeled or interpreted from the point of view of a caribou herd migrating south rather than perceived through the eyes of an oil company executive.)

A second use for models of systems is to establish correspondences between abstract, analytical notions and experiential, synthetical notions. One may model the operations of a food-producing system (a farm, a garden, a plant) in terms of the propagation of usable energy and useless energy. This model invites the association of descriptions of energy distribution within the model with the distribution of output to external systems.

A model may help to expand or to generalize a more familiar system into a continuum with the system being modeled. The workings of a clock may be quite familiar; its use as a model for the processes of generation (winding) and degeneration (winding down) of energy in more complex items may suggest a continuity between mechanical and organic systems levels. Metaphors and rules determining the behavior of a clock may be a special case of the larger, organic structure (say, a factory). Models and the systems they represent may be continuous in other ways. Systems language has a syntax whose logical structure resembles the structure of the system being described (or prescribed). The design of a model from which to plan an environmentally sound lifestyle may involve formulating rules, purposes, and information networks that will have to exist as actual constraints and directions for human behavior.

Achinstein provides a summary statement on models--he argues that there is no single definition of a model; rather, there is a "common element" running through descriptions of the models people utilize that can provide a universal statement about all analogies that is both necessary and sufficient. Models are (or contain) "(1) a representation of system X; but (2) one that is either not literal, or not faithful in all respects, or not complete, and may represent X in some 'indirect' manner; and (3) one that utilizes something more or less familiar, known, understood, readily grasped, or easily experimented upon."[6] In a theoretical model, X is represented only approximately by using familiar theories. In an imaginary model, X is represented but not literally, by imagining how X could satisfy certain conditions where those conditions are familiar or understood. Again, in an analogy (the paradigm case for models), X is represented in an indirect way with some familiar or understood item.[7]

The language of the systems provides elements and syntax for the building of models and analogies for, in this case, "the understanding of human/environment systems related to the environmental problem configuration." Certainly, this language may be used in other contexts. The difficulty with the systems language, or with any other language based on analogy, is the problem of the carryover of meaning from the original literal use of the language into the subject matter that is allegedly analogous. Symbols ("energy source," "interaction," "heat sink,"), and themes ("system," "cycle," "systemic evolution"), are, upon examination, terms derived from engineering. Despite the fact that they have been broadened and softened for application to human behavior, the definitions here can be construed in mechanistic ways.[8]

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[6] Peter Achinstein, Concepts of Science: A Philosophical Analysis (The Johns Hopkins Press, 1971), p. 257.

[7] A full, and critical discussion of models and analogies may be found in Achinstein, Chapter 7; Nagel, Structure of Science, pp. 90-97 and pp. 107-117; Mary B. Hesse, "Models in Physics," British Journal for the Philosophy of Science, 4 (1953), pp. 198-214; Max Black's Models and Metaphors, (Cornell U. Press, 1963).

One of the underlying assumptions of the language presented here is that "systems" are more like flowing streams than railway bridges. Nevertheless, the analogies when examined critically are closer to the mechanical than to the biological.

The reader should also be clear about the necessarily simplified nature of the symbols, syntax, and definitions presented here. Empirical descriptions are limited in many respects. For example, language (whether scientific or ordinary) cannot capture process or change. Systems language is no exception to the inadequacy of language in general, despite claims of "wholeness." Even in the best of systems analyses and descriptions, much approximation has to occur. For example, normative judgments are excluded from systems language for the purposes of "simplicity." Reasons for action--laws, manners, morality, etc. are reduced to general terms such as "feedback." It can be argued that "feedback" and "input" and other terms can be arbitrarily defined to include social/cultural conflict, deep structures, moral ideals, and psychopathology. The difficulty is that a single metaphor is used to cover a multitude of significant items. Social, racial, or class conflicts may therefore be construed as social engineering problems of information regulation, rather than as real crises.

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[8] See the discussion of the goal-directed behavior in John V. Canfield, Purpose in Nature. (In particular, see the papers by Rosenblueth, Wiener and Bigelow, pp. 9-16 and Scheffler, pp. 48-66.) von Bertalanffy, in General System Theory (George Braziller, 1969), p. 150, argues for a biological model of the open system which is contrasted to the idea that "information" used in feedback cycles (q.v.) can adequately describe purposeful, self-organizing behavior.

von Bertalanffy says that his model is modeled on biological processes; specifically, that order is maintained in the "metabolism and (the) exchange of components." Systems model characteristics are dependent upon the elements chosen to be utilized in the construction of a model. Cf, Ernest Nagel, pp. 428-446 on the debate between "mechanistic" and "organismic" biology.

Unconscious, or "reflex" activities, authority pressures, fear of sanction, anxiety to secure a goal--all of these are socialization and acculturation processes that can have complex and conflicting effects on the development of models as a basis for designing policy, whether personal, social, or ecological.[9] Distinguishing and synthesizing these factors may complicate a systems design or description to the point where it is untenable, or useless. A useful systems model, therefore, requires simplification, and simplifying complex realities involves choices that may beg the question or may be completely arbitrary. Nagel states that "some unessential feature of a model...may be mistakenly assumed to constitute an indispensible feature of the theory embedded in it; and the model may be confused with the reality itself."[10] Hence, the theories describing or explaining natural cycles, or the social/cultural theories relating human consumption and attitudes toward nature might be exploited in unprofitable directions, and the operative significance of the theory can be lost.

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[9] An interesting contrast can be made between Erich Jantsch, Design for Evolution, Part II, "Design: The Human Way of Relating to the World," and Georg H. von Wright, Explanation and Understanding, pp. 132-167.

Uncritical adherence to an untested (possibly untestable) model-building logic such as systems language can lead one to think there is a "real" elegant structure underlying (in some sense) the vagaries of empirical reality.

A coherent and clear model must not mislead one into thinking that what exists is as straightforward and parsimonious as the model. The belief that systems language requires no independent research can lead to irrelevancy. Moreover, this belief can result in a systematically misleading rhetoric wherein the use of language ascribing change to a system is a substitute for real change.[11]

There are additional difficulties involved with many of the terms to be defined here. Individual system components/relations can be clearly defined in terms of their functions. However, the discussions of "wholeness" should be studied carefully. Various statements such as "Systems exist in a steady state of 'dynamic equilibrium' with their environment," or, "Systems are organized hierarchically and mutually dependent in causal and other complex ways" must be examined for their operational and definitional significance. Moreover, the truth or falsity of these statements must be based on more conclusive evidence than exists at present. It should be stressed that systems analysis and design have not excluded either by logical argument or empirical evidence more "analytical" approaches to the humanity/environment problem. Useful models can be constructed in such a way that an observer can connect significant events in a non-systemic way that still makes clear all the causal ramifications that ought to be accounted for.

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[10] Nagel, Structure of Science, p. 115. We may legitimately ask, "What is the theory being represented by systems language?"

[11] Henry Levin, "A Skeptical View of Qualitative Education Planning," prepared for the International Institution of Educational Planning, Paris (October 1976).

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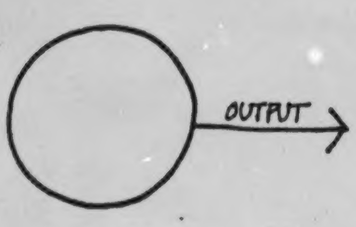
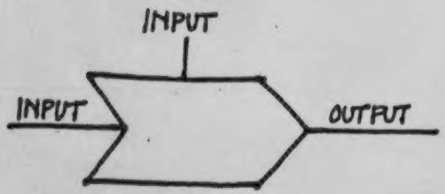
C. SYSTEMS DIAGRAMMING

A series of symbols that can be used in diagramming systems is presented in this section. They are based on the work of Howard Odum.[12,13]

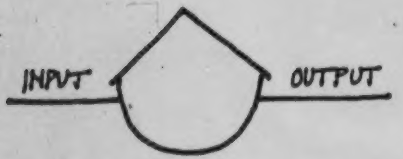
The use of these symbols in simple diagrams clearly depicts how the parts of a system interact with one another and with their environment. For example, a farm is a system that can be diagrammed to show its requirements and its food production. The symbols used for such an energy flow diagram are the following:



Energy source. The circle indicates a source of energy outside system, i.e., the sun. The line represents the energy pathway.



Interaction. This symbol shows the interaction process of two or more kinds of energy, i.e., sun, rain, soil, human work, and machines interact to produce high-quality energy (food).



Energy storage. Some kind of energy such as materials or information, is stored within the system, i.e., nutrients "stored" in the soil.

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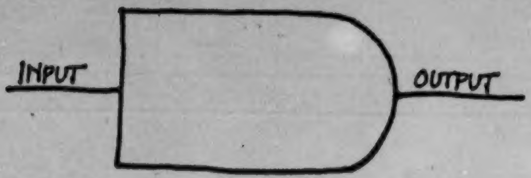
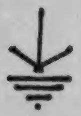
[12] Howard T. Odum, Environment, Power and Society (New York: Wiley-Interscience, 1971).

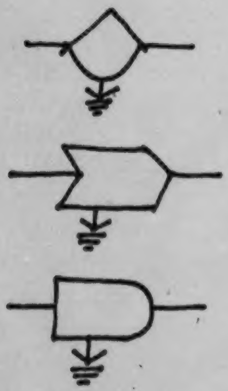
[13] Howard T. Odum and Elisabeth C. Odum, Energy Basis for Man and Nature (New York: McGraw-Hill Book Co., 1976).



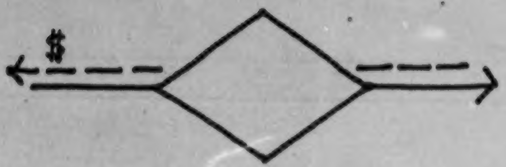
Production. This symbol reflects the production role of a subsystem. It can be used to represent a green plant, or it can represent the entire food production subsystem of the farm incorporating interactions and storages within it. It is self-maintaining.



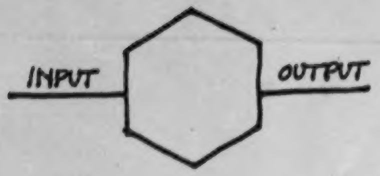
Heat sink. The arrow pointing downward symbolizes energy that can do no more work in the system. It is the loss of energy.



The heat sink symbol is attached to every storage, interaction, and production symbol.

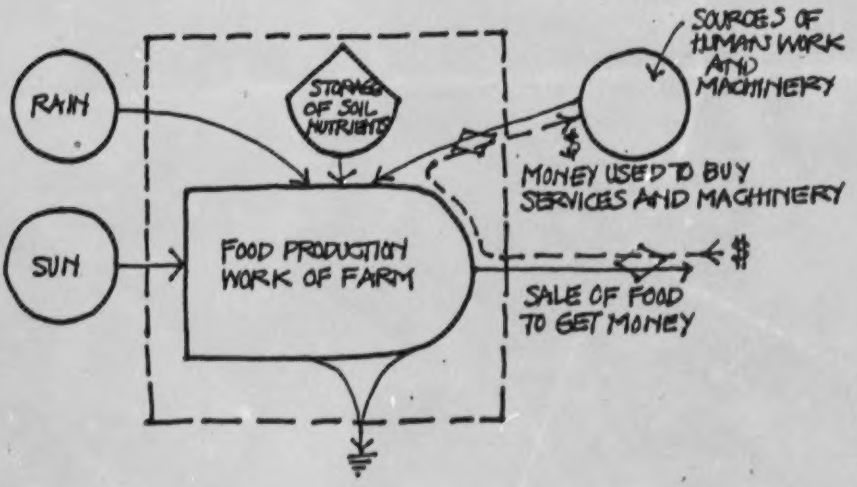


Money transaction. This symbol indicates flow of money in one direction to pay for energy flow (of materials) in another direction.


INPUT
OUTPUT

Consumer. This symbol represents a system that has some storage capacity and offers some feedback flow. It makes use of the high-quality energy produced. It is self-maintaining, i.e., a town or a user/consumer.

Using these symbols, some processes of the farm system can be shown as follows:


RAIN
SUN
STORAGE OF SOIL NUTRIENTS
FOOD PRODUCTION WORK OF FARM
SOURCES OF HUMAN WORK AND MACHINERY
$
MONEY USED TO BUY SERVICES AND MACHINERY
$
SALE OF FOOD TO GET MONEY

The use of these symbols avoids confusion and results in the explicit depiction of interactions and energy flows. Systems diagramming is a means of visualizing the behavior or whole systems.

D. GENERAL SYSTEMS THEMES

General Systems Theory is an organizing concept for a holistic approach to environmental education. Its contribution to integrative education is described by von Bertalanffy as follows:

> The educational demands of training 'Scientific Generalists' and of developing interdisciplinary 'basic principles' are precisely those general system theory tries to fill. They are not a mere program or a pious wish since, as we have tried to show, such theoretical structure is already in the process of development. In this sense, general system theory seems to be an important headway towards interdisciplinary synthesis and integrated education.[14]

Certain general principles are common to all systems and can aid in the understanding of human/environment systems related to the environmental problem configuration.

The following general systems themes are discussed in this section:

- System
- Interactions
- Cycles
- Feedback
- Equilibrium
- Hierarchy
- Systemic Energy Flow
- Systemic Evolution

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[14] Ludwig von Bertalanffy, General System Theory (New York: George Braziller, 1968), p. 51.

Each theme is defined and discussed in terms of its systemic properties. Several interdisciplinary examples of each theme are provided, as well as a sample application of the themes to an environmental problem area.

1. SYSTEM

Perhaps the most fundamental definition of a system is that it is "a set of elements standing in interrelation among themselves and with the environment."[15] These elements function as a whole by the interaction of the various parts.

All living creatures are examples of systems. The human body is a system; so is the amoeba. The family, the classroom, the stock market are kinds of systems too.

What do they all have in common? What makes them systems? What are their differences? What is "systemness?" These questions are addressed in the following discussion of the types and taxonomies of systems as well as the descriptions of three properties of systems:

- Boundaries
- Entities
- Input/Output

Essential to the definition and discussion of systems is the idea that the system is an indissoluble combination of structure and process, made up of parts and relations. This means: 1) a system functions as a whole by interactions of its parts; and 2) no system is either structure or process, matter or energy, but rather is both. People often insist upon separating the concepts in a dualistic fashion, dwelling on one extreme or the other in order to exclude either structure or process--thereby violating the holistic nature of things.

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[15] Ludwig von Bertalanffy, Trends in General Systems Theory, ed. George Klein (Wiley-Interscience, 1972), p. 31.

To counteract this tendency, the word "structurprocess" will be used here. Everything conceivable in reality is structurprocess, which incorporates the seeming duality of nature.

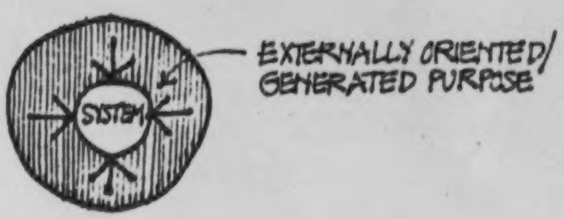
a. Types of Systems

Among the types of systems are natural and artificial systems. Most of the things that are considered "the furniture of the earth" are natural systems or parts of natural systems: stable atoms, molecules, cells, multicellular organisms, and ecologies. An ecosystem such as a lake, pond, forest, field, or desert is a natural system.

Many of the things that we regard as "the furniture of people" are artificial systems: governments, methods of marketing, educational institutions. Social systems such as the family, classroom, church, or country club are artificial systems.

A natural system has a function designed by the nature of its environment. It has an externally-oriented, externally-generated purpose. This means that the function of that system has been influenced by the things around it so that its components or elements act in a manner consistent with its allowed place in the total environment.

No conscious intent caused the purpose in this case--only the random probabilities of systems surrounding it. In other words, the elements have come together because that is the only way they can survive in their environment. Therefore, the purpose is oriented toward survival--not by the designs of the system itself, but rather by the imposition of probablistic constraints by its environment. These types of systems are continuously generated by nature.



"NATURAL" SYSTEM

In an artificial system the purpose comes from the inside. It is an internally-generated, internally-oriented purposive system. People set up connections because they want them that way. In some cases the connections may not be even related to the survival of people. An auto has a purpose, but it is artificially kept functioning or stable by people to fulfill their purpose. If people go, it goes. It is not continuously generated by nature without people.

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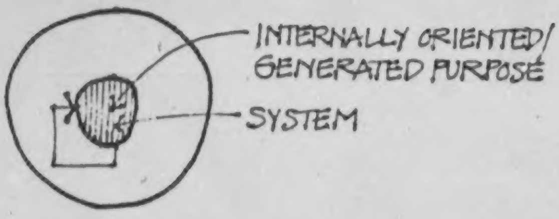
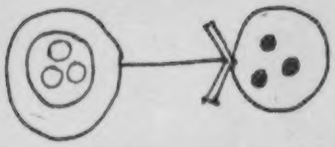


"ARTIFICIAL" SYSTEM

People often mistake the origin of the purpose of a system. They ascribe origin of purpose to a supreme being, themselves, or the higher animals setting a goal for a particular system. It is the teleological and religious origin of purpose that held back the perception and understanding of many natural laws, including evolution, for long periods of human history.

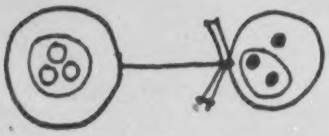
A further distinction among systems has to do with the decomposability of the entities, or parts of the system.

Decomposable: Some systems can be broken down into their constituent parts.



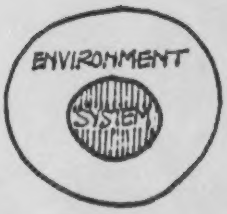
DECOMPOSABLE

Nearly Decomposable: Some systems can be broken down into clusters or clumps of their parts but not their most fundamental parts.



NEARLY DECOMPOSABLE

Non-Decomposable: System acts as one entity as a process. It is impossible at present for people to detect the various parts. Human spirit, a transistor, and an analog computer are examples.



NON-DECOMPOSABLE

Non-decomposable systems are the hardest for people to understand. At one time, many systems primitive people thought were non-decomposable actually turned out to be decomposable when people had advanced enough to detect the parts and their modes of interactions.

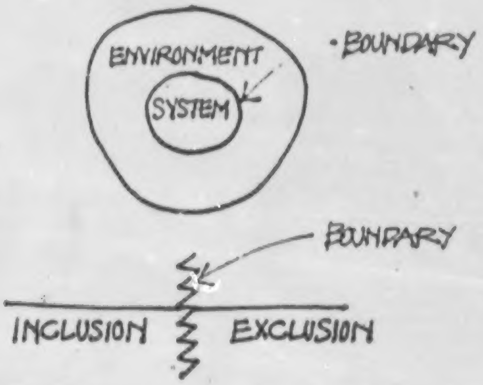
All three of these types of systems are holistic. Because the parts of a system can be "seen" does not mean that they cooperate any less to function as a whole.

Keeping in mind these three types of systems, we can attempt to understand how a system comes into being and how it maintains its "systemness" by examining three systems properties: boundaries, entities, and input/output.

b. Boundaries

All systems have boundaries. Any one system does not exist distributed throughout the universe at once. It does not include all things, just those that are related in the manner that defines the system under consideration.

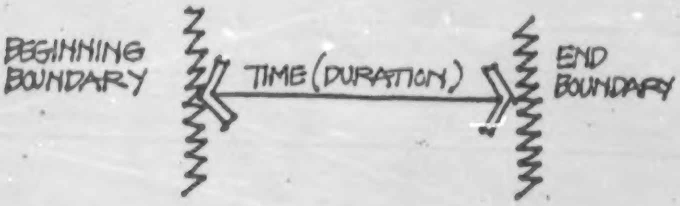
A boundary is a line or area at the perimeter of a system that holds together the components of the system. It protects them from environmental stresses and excludes or permits entry to different kinds of matter such as energy or information.



Boundaries can be artificial or real/actual: Artificial boundaries are often equated with conscious decision-making because the decision-maker can include in boundary definitions of a system only what he or she feels should be included. We call these humanocentric boundaries because they are centered on a human's point of view. These do not always match nature's boundaries, which can be defined as real/actual.

Both artificial and real/actual boundaries are parameter-dependent, that is, they are determined by time, space, or operational influence. Different boundaries of approximately the same system can be indicated by the use of different parameters. Man's limitations in sensing these parameters in an unbiased way increases the difficulty of defining real/actual systems boundaries in an ideal manner.

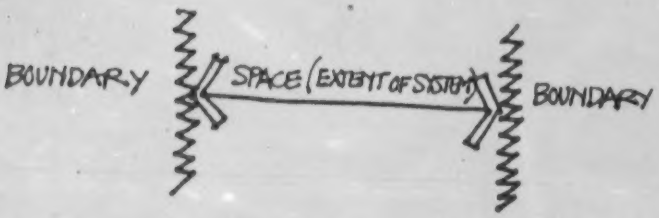
Temporal boundaries define a system that acts together for an observed length of time. For example, subatomic particles last on the order of 10-12 seconds, while astronomical bodies such as stars remain a stable system for about 8 billion years. Various levels of biological organisms (molecule, organelle, cell, tissue. organ, organism) last for characteristic lengths of time as shown below.



TEMPORAL BOUNDARY

Since these cycle lifetime values overlap, and since only classes of systems, not individual systems are resolved, it is clear that more than temporal boundaries are needed to define a system.

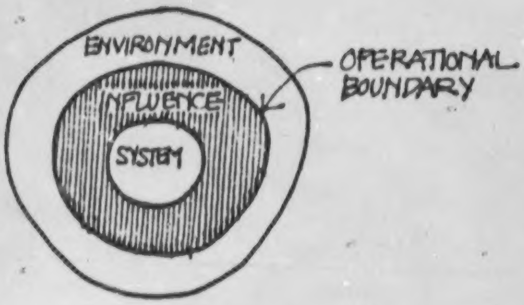
So, we turn to spatial boundaries to help define systems. Most systems recognized at this time exist in a measurable space. Cells are bounded by membranes, humans by skins, nations by boundaries, galaxies by concentrations of matter, energy rays by paths, etc. Even dynamic processes, if mapped over time, would be constrained to the space in which the processes act most often.



SPATIAL BOUNDARY

There are, of course, exceptions. That is why the concept of system is described as a pattern--the general picture remains the same, despite particular eccentricities.

Operational influence boundaries are based on the observation that the parts in a system perform certain objectives or functions and these influences can be considered to have realistic limits. This is a difficult concept because it requires "visualization" of the furthest extent of influence of the dynamic processes of a system. Many of these processes are recognizable only after years of patient study by experts. Still this is possibly the most precise of all parameters of boundaries.



The most correct or "actual" boundary of a system would come from summing together all boundary condition definitions such as temporal, spatial, influence/operational, tempered by an awareness of humanocentric influences. Even then there can exist a fuzziness in the definition of actual systems boundaries, since the same part may be used in two different systems, and since many whole systems become parts (subsystems) of larger systems.

c. Entities

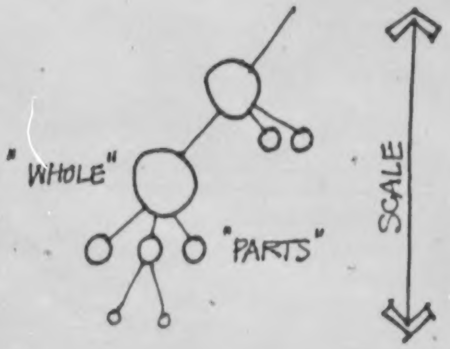
Every system is comprised of parts, elements, or entities. Boundaries describe these parts of systems as discrete structures of "bounded structurprocess."

Implicit in the idea of "parts" is the "wholeness" of the system. It is a set, a unit, an assembly, arrangement, or subsystems. As was discussed earlier, the system may be decomposable, nearly decomposable, or non-decomposable. However, it is important to note that a system may be structurally decomposable while being functionally non-decomposable. This is a most important insight because it proves that although a system can be seen as consisting of subsystems, the whole is not equal to its parts.

For example, consider the DNA molecule. It can be structurally broken down into its nuclear subunits, but anything less than the molecule has no information and cannot function; the molecule is non-decomposable. Therefore, what it does is not understandable if you look at anything less than the whole molecule.

In the physical sciences, this idea is reflected in the concept of "ultimate indivisible particle." This "atomistic" particle is the smallest discrete part of an element that is not capable of further subdivision without loss of identity as an element.

In systems theory, the individual element or entity is seen as a tool to describe the structural components of a system, a "whole."



STRUCTURE

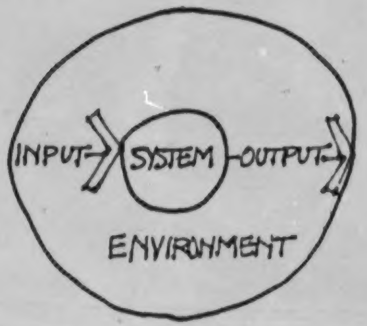
There is a danger in isolating the object, or part, to be considered--at the expense of considering the whole. It is necessary to remember that what is an element or a whole system on one level (e.g., a cell) is merely a subsystem to the next level (e.g., tissue). A part of a greater whole is itself a whole to the parts below it. This is the concept of "nested systems," a system within a system, such as a child who is part of a family system that is in turn part of a larger community system.

This more precise definition of an entity involves the relationships between one entity and other entities. This results in a new, more systems-oriented concept of entities as not merely structure, but rather structurprocess, the parts and inter-relations of parts in the system.

It would be difficult to define a system without reference to its parts. The concept of "system," although oriented to a description of wholeness, is actually dependent on the concept of more than one intimately interlinked, but still discrete elements.

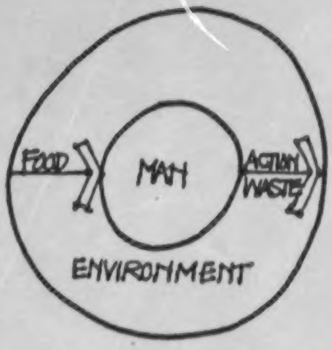
d. Input/Output

Because they are "bounded," does not mean systems are isolated from their environment. In fact, they are entirely dependent on their environment. Most systems, whether physical or biological, are adapted to their environment. Their form and function are compatible with the supplies of energy, materials, or information the environment has in quantities sufficient to sustain them. By the same token, the system returns transformations of the energy, materials, and information it receives from the environment back to the environment. Systems theorists have generalized these interactions of a system with its environment to two major categories--input and output.



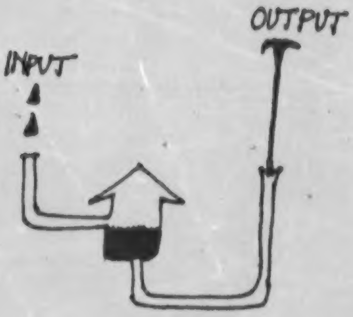
The pattern of input and output of the system relates to the dynamics, the flow of matter or energy through the system. In this process, transformation takes place.

In most cases, input-output transformations are essential for the survival of the system. A simple illustration of this would be the cycle of food taken into the body when we eat (input quantities), transformed into us and our actions with unused portions expelled in the form of waste or sweat (output). The input-output generalization may seem overly simple, but as a diagnostic device it can be effective in focusing attention on why a system is malfunctioning.

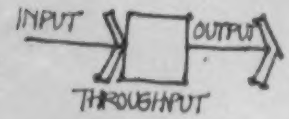

FOOD
MAN
ACTION
WASTE
ENVIRONMENT

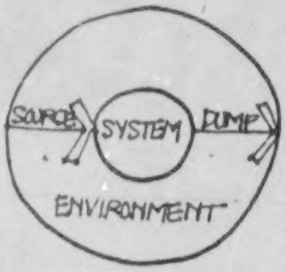
The systems for utilization of certain natural resources provide a striking example:

OIL - Show input rate and output rate of oil usage and its effect on oil reserves and our dependence on stability of the reserve. Explain how long it took in geologic time to form the oil (input) as compared to the rate of exhausting or using the oil (output). Input rate = 2 to 3 billion years to form. Output rate = 200 years to use; a great imbalance.


INPUT
OUTPUT

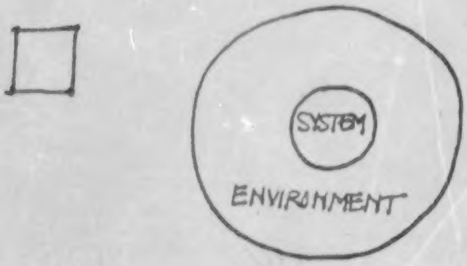
On the basis of input and output flows we define systems as being open or closed. An open system has resources and energy that flow through the system; things act on it, it processes things. It has an intimate relationship with its environment, which acts both as a source and a dump. It has both input and output flows.





OPEN SYSTEM

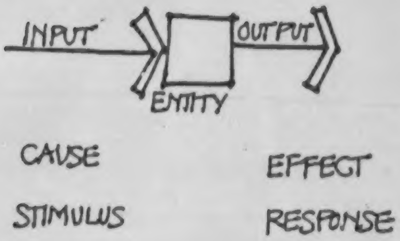
A closed system is totally isolated from its environment--receiving nothing, yielding nothing, no inputs, no outputs. In actuality, a closed system is only a theoretical construct. No one has ever been able to identify a truly closed system totally isolated from its environment. Even a rock resting on a mountain top for eons is acted upon by the temperature and gravitation that flow through it.



CLOSED SYSTEM

In the past people have treated many things as closed systems that were actually open systems. Without knowledge of a set of patterns, such as those in the content of this training model, to alert people to the fact that in whatever system is being designed or exploited there will be input-output, there is a good possibility people will miss them or find it convenient or profitable to ignore them.

The concept of input-output, and a system's dependence on it, can also be used to explain why interrelationships between real systems are so many, so varied, and so important. Input-output couplings actually generate the network of causes and effects in systems for a whole.



In summary, the types of systems discussed in this section are:

- NATURAL: externally oriented, externally generated;
- ARTIFICIAL: internally oriented, internally generated, purposive;
- DECOMPOSABLE: broken into parts;
- NEARLY DECOMPOSABLE: broken into clusters of parts;
- OPEN: input and output flow;
- CLOSED: no input, no output.

A few concrete examples from real systems are included here to help in understanding the initial, more abstract definitions of the theme. The examples cover many disciplines and reflect the categories discussed in this section. Similar specific examples of the themes could be found in all other known or unknown systems. The examples here are not exhaustive in any sense; they are merely introductory.

EXAMPLES OF SYSTEMS

ASTRONOMICAL: Perhaps the oldest system to use the title of system is the solar system. Planets, stars, galaxies are all systems with assigned boundaries, inputs, and outputs.

BIOLOGICAL AND ECOLOGICAL SYSTEMS: All living creatures are examples of systems.

Our bodies are bounded by their structure, by our covering of skin. We do not extend everywhere, we are in one place and nowhere else. Even our ability to influence things around us has well-defined limits. We cannot influence beyond our voice or other action-oriented capabilities. These are our influence or operational boundaries. We may think we can do much more than we can actually do. The limits of what we can actually do are our actual boundaries, and these do not always agree with our own ego-centric or humanocentric boundaries of what we can do.

Our bodies require input--food for the body, and encouragement and reinforcement for the spirit. Our bodies produce output. Sometimes this comes in the form of our communications and actions with others. Sometimes it comes in the form of unneeded wastes such as sweat, feces, urine, cut hair and nails. Even when we die and decompose, our disassembled constituents are our final output, serving some other system as input.

We only exist in a certain civilization at a certain period of its development, and at a certain time in the evolution of mankind and even the universe. Within that space, we exist for only a small length of time--our lifetime, our life cycle. This is the temporal boundary of our system. If we did not last at least for some recognizable time, we would not last long enough to be experienced.

Because we take in inputs and release outputs we are an open system--we are "open" to acceptance of energy and energy materials. Information flows through us and is processed by us.

Our bodies are also purposive systems. Our purpose is to stay alive as long as possible, and we are committed to creating order out of chaos because we are ordered. An ordered environment favors our survival. We are also teleological systems because we seek to achieve ends (telos) and manipulate the world around us to get our way. We are centralized and symmetric systems because we have one head, but have pairs of eyes, ears, kidneys, feet, etc., all placed evenly on a longitudinal line drawn through the center of our bodies from our head to our toes.

Since we are purposive, we have internally-generated goal systems. We can decide what we want because we have free will to choose between courses of action. Most of the animals have externally-generated goals that have been established by generations of rigorous selection by nature without the animals' conscious intervention.

Our bodies are decomposable. They have distinct parts (entities/components/elements). For example, on one level our bodies are composed of distinct and separate organs such as the brain, heart, lungs, liver, kidneys, eyes, muscles, etc. On a still finer level each of these is made up of specialized cells. These "parts," through their interactions, make up the unit or wholeness that is us. The fact that we can distinguish one part from the other and distinguish their functions makes us decomposable to our parts. Our spirits are different. Throughout history people have not been able to figure out any parts of which our spirits are composed. It seems to be all one wholeness, indivisible. Thus our spirit is non-decomposable. So we seem to be examples of both a decomposable and non-decomposable system at one and the same time.

In summary, it is clear that we have all the attributes of the concept definition of a system, and therefore we are very similar to all the other systems in the universe, big and small.

There are many examples of systems boundaries in biological organization. For example, the boundaries of the cell itself caused by the separation of environment from cell constituents by the dynamic and selective permeability of the plasma membrane. Such organelles as the mitochondria, the chloroplast, and the nucleus, are all systems in themselves, separated from the rest of the cell by their own membranes. The organ-body relationship is another example of distinct gaps between a systems organization at one level (organs) and that of the next level of system (the organism).

Ecosystems are non-purposive systems. Energy, originating from the sun, flows unidirectionally through ecosystems. Chemical substances continuously cycle within ecosystems. Any ecosystem includes a multitude of living organisms, belonging to many different species. Ecosystems typically respond to perturbations evolving on a historical to geological time continuum. Man, however, may disturb ecosystems through chemical effluents, urban wastes or habitat modification on a much more compressed time scale--sometimes over periods of less than a week as with oil spills and blowouts. The spatial boundaries of an ecosystem may be clearly defined as the shores of a lake, or arbitrarily placed as in the forest-grassland transposition. The temporal boundaries of an ecosystem may be ecological (what can be studied and understood within one person's life) or evolutionary (involving perhaps centuries of change).

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ECONOMIC SYSTEMS: Economic systems exchange materials and wealth between either functional or geographic components. Economic systems are bounded in space (i.e., the U.S. capitalist economy) and are temporally bounded to include either long-term or short-term profits. The functional components of economic systems include buyer, seller, producers, distributors, etc. Spatial components of the global economic system are represented by countries. External management of economic systems may impose different goals. A capitalist seeks to maximize profit whereas a socialist seeks maximal equal distribution of wealth.

The globe is a closed economic system in terms of cash flow whereas individual countries are open systems. Economic systems typically exclude ecological concerns since dollar flow is not associated with most natural services. The inputs/outputs of economic systems determine costs, cost-benefits, profit margins, etc. The allocation of resource input/outputs are strategies for maximizing dollar profits.

URBAN SYSTEMS: A road network carrying people and goods can be readily described as a system. The boundaries of this system can be defined continentally, nationally, regionally, or locally as portrayed on a map showing the connecting of all routes as well as all points of entrance or egress from the system.

ENGINEERING SYSTEMS: A nuclear power plant can be considered a system. The boundaries are drawn around the area the plant occupies. The input to the plant is in the form of uranium fuel, manpower, materials, etc. The plant has the ability to store these quantities, and the output is in the form of electrical energy, waste heat, and materials.

SYMBOLIC/PHILOSOPHICAL: Languages are communication systems bounded by the set of all the recognizable abstract symbols. Though modern language systems may seem to lack input in the course of their evolution, new symbols and grammatical structures are added.

SOCIAL SYSTEMS: The family is a well defined social system with boundaries determined by degree of relationship. Families can be nuclear or extended. Families are open systems with an internal purpose of survival. Input/output of family systems may be energy, matter, or other persons.

The education system is a social system bounded by those it serves and those resources of information upon which it draws. The goal of the education system is the distribution of knowledge. The people educated may be a very restricted class or an entire population.

The country club is a very special social system for recreation between hypothetically compatible people. The purpose or goals of a country club are variable--from fun to status to the cementing of business relationships.

2. INTERACTIONS

Returning to von Bertalanffy's basic definition, we see that a system is defined as a "set of elements standing in *interrelation among themselves and with the environment*."[16] [emphasis ours]. This interrelation is a connection, a series of linkages, that facilitates *interaction*.

There is a network of connections from the smallest to the largest of all possible systems. These connections give unity to a subsystem and integrate it into "one." The links involve the input/output, the "flow" between the parts of a system or between systems.

"(A system's) integrity is created and maintained by linking its components by channels of transfer through which pass data, information, materials, and even organisms. For example, the neural network of the human body carries patterns of data from one region to another, so the body responds as a whole to local effects. Blood vessels serve as transfer channels to carry food and oxygen to the cells and to carry waste products away. In a society, the transfer of information occurs through such means as telephone and the mails, while people and things move by aircraft, highway, rails, and pipelines."[17]

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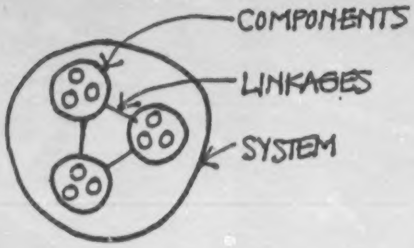
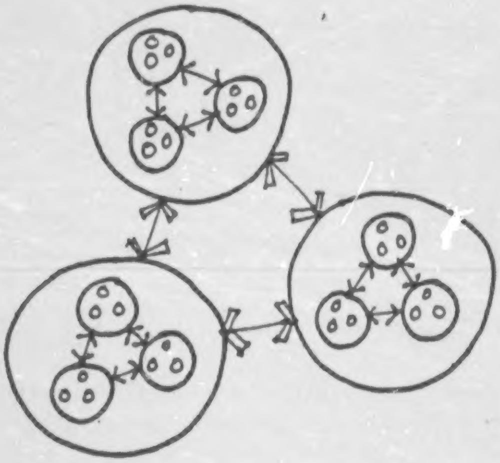
[16] von Bertalanffy, *Trends*, p. 31.

[17] James F. Mortyn, ed. "The Nature of a System," *Earth 2020 Faculty Institute Workbook*, 1974, p. 9



STRUCTURAL LINKAGES

However, "the relationship between components or subsystems within the system is usually not a simple linear chain of cause-and-effect. Typically the interactions among system components are multi-dimensional and complex, so that a change in one component may produce many effects, both large and small, in other components of the system."[18]



SYSTEMS INTERACTIONS

When the concept of interactions is examined, it quickly becomes obvious that the number of possible connections in environmental systems, human systems and the supersystem of both is astronomical. Even in a system of only 100 elements, the possible interrelations are 2^{100}. In human-environmental systems the number of classes of elements alone is astronomical. So, the number of possible interrelationships is clearly beyond human comprehension.

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[18] Mortyn, "The Nature of a System." p. 9.

But, since all elements experiencing interrelationships are systems, the astronomical numbers of connections can be simplified into a manageable number of classes of interactions.

This section will introduce some definitions of types of interactions common to all systems and to human-environment systems in particular.

a. Coupling, Linkage, Interrelationships

Coupling, interaction, linkage, and interrelationships are words that are often used synonymously. But, distinctions can be made among them. Interaction is a general term that subsumes any kind of influence or connections among systems.

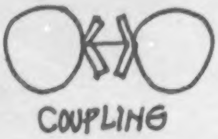
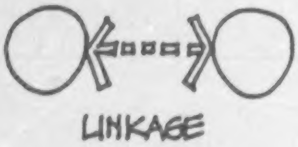
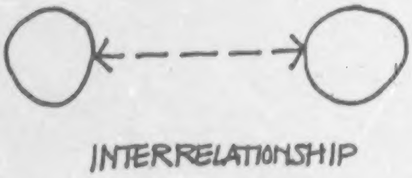
Three types of interactions are:

- Coupling
- Linkage
- Interrelationships

Coupling implies direct, immediate, and more mutually casual relationship than what is implied in the other words. The word "coupling" is used for the intimate interaction among parts of a system--between subsystems of a system. It is this tight coupling that makes a whole of parts. Coupling is an intrasystem relationship. It is now, however, restricted to a connection between two entities. As it is used here, coupling often signifies interaction among several subsystems. This type of coupling among several components or subsystems is called network coupling.

Linkages and interrelationships are inter-system interactions. They are less intimate connections, weaker, and spread over a longer distance. In an interrelationship the connection may just be an influence.

These distinctions are outlined in the following chart:

	COUPLING stronger, short distance, flow both ways between subsystems makes a wholeness or system.
	LINKAGE weaker, longer distance, flow can be one way or both ways, can make a supersystem.
	INTERRELATIONSHIP much weaker still, farther distance, can be one way flow, does not necessarily make a supersystem, may just be an influence.

Again, when considering systems, subsystems, and supersystems, it is important to maintain a certain perspective: what is an inter-system linkage between whole systems when seen from the perspective of the coupled parts of each individual system may actually become intra-system coupling when seen from the perspective of a supersystem on the next higher level which evolves from the whole systems.

How then, are the types of interactions distinguished? There are parameters to distinguish subsystem couplings from supersystem linkages and interrelationships. These are: interaction distance, interaction time, and interaction energy or strength. All three parameters must be taken into account simultaneously to define the type of interaction.

Strength is not always related to distance, however. Coupling, which links parts of a system, is not always strong. In fact, it is better for a dynamic, changing system to have a balance between strong and weak coupling. Strong coupling is good for the stability of a structure, but weak coupling gives adaptive capabilities to the supersystem. We will further explore the consequences of these couplings in the section on Systemic Evolution. For now it is enough to recognize that to have a dynamic, evolving change or even an active structure, there must be a structural basis in strong coupling that has to be married to an appropriate dimension of weak coupling.

By the same token, interrelationships, which are connections over a greater distance, can have a very strong impact/influence on a system's behavior.

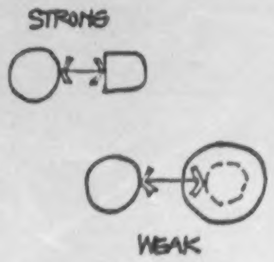
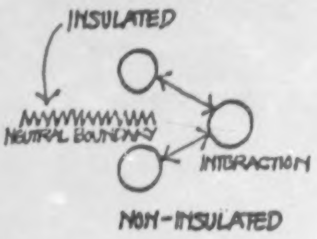
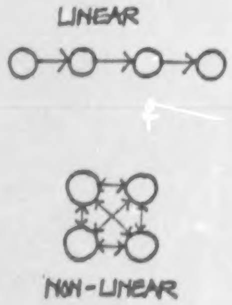
In general, however, it can be said that a strong interaction is one that is so high in energy investment that the normally encountered free energy of the environment around the system cannot disengage the connection.

A weak interaction is one that is low in energy investment. It is of the same magnitude as that in the surrounding environments, so that the interactions are influenced by environmental changes.

Further distinctions can be made as to whether the interaction is insulated or non-insulated, linear or non-linear. These distinctions are described briefly in the following chart.

The introduction of the concept of interactions should temper our enthusiasm for an oversimplified concept of "boundary conditions" as the prime indicator of systemness. The couplings of the subsystems to make the system are the mechanics of unity or wholeness. The interrelationships of the system with other systems are also part of the wholeness they help sustain.

Understanding the important role of interactions and linkages in defining unity and wholeness could free people from an ancient mind set, or from reliance on the supremacy of structure for that purpose. The shift in focus may sensitize people to the importance of dynamic process based on linkages and couplings in defining an entity. The word "structurprocess" is the ideal word to describe wholeness with neither stable form nor dynamic process as the dominant phase.

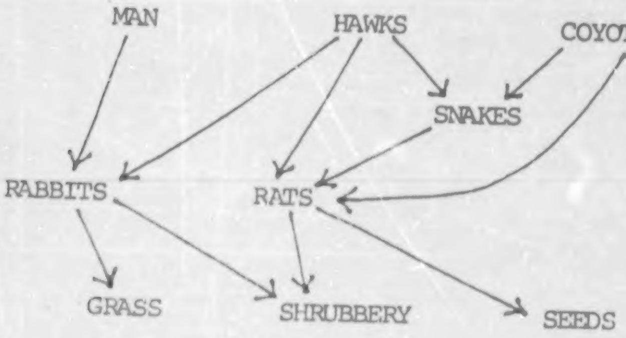
	**STRONG** Couplings so high in energy investment that the normally encountered free energy of the environment around the system cannot disengage the coupling.	**WEAK** Couplings low in energy investment and in the same order of magnitude as the surrounding environment such that they are influenced by enviromental changes.
 INSULATED NEUTRAL BOUNDARY INTERACTION NON-INSULATED	**INSULATED** An interaction or flow is insulated if a boundary neutral to the energy flow, or the entities being bounded is interposed between the interaction and the systems environment.	**NON-INSULATED** Negative of insulated. No neutral boundary. Interaction of the system is exposed to the environment.
	**LINEAR** The simple unidirectional cause and effect between two elements. All other parameters can either be held constant, or their influence on the linear cause and effect can be quantified.	**NON-LINEAR** Complex networks of potentially simultaneous causes and effects. All elements and processes tend to adjust to each other instantaneously and simultaneously. It is impossible to look at all the linkages at the same time to determine what casual flows exist.

EXAMPLES OF INTERACTIONS

ASTRONOMICAL SYSTEMS: Gravity is the universal linkage through which every celestial body is coupled to every other celestial body.

BIOLOGICAL/ECOLOGICAL SYSTEMS: Subsystems are linked through a variety of functions and processes. It is the nature and complexity of these linkages that confer stability onto systems as well as contain emerging surprises for people when they tamper with what might appear to be only an inconsequential component of the system.

Feeding on another organism is a necessary and pervasive linkage in the natural world. Patterns of feeding for a collection of species permit the derivation of food webs. An example of a food web is illustrated below:



Even such simple linkages as food webs provide a powerful tool for predicting the fate of toxic chemicals such as DDT. The inevitable concentration of DDT in top level predatory birds is obvious from the most superficial of food web analyses. Yet as a result of our failure to foresee the problems with DDT our national bird, the bald eagle, is the most chemically polluted bird in the Americas and is in grave danger of extinction.

ECONOMIC SYSTEMS: Economic systems are pervasively linked to natural resources and energy. Without energy to process raw material there could be no exchange, no accumulation of wealth, no profits. Buyers, sellers, producers are all coupled in economic systems. The coupling is so intricate that economics is an uncertain science full of emergent surprises. Markets represent couplings between buyers and sellers.

SYMBOLIC/PHILOSOPHICAL: Linkages in language form the syntax structure of usage. Words derive their meaning from the other words with which they are linked in a sentence. Some linkages or couplings are so common that they are formalized, as in contractions: cannot = can't; are not = aren't; etc.

SOCIAL SYSTEMS: Every member in a family is coupled in close relationships. As the social group gets larger, extending to a neighborhood, the number of couplings becomes larger but the strength of each coupling is on the average weaker.

3. CYCLES

So far, the discussion of energy flow has been limited to the linear movement of input and output between systems or between entities of a system.

This section will consider the cyclical flow of energy in a system. Since many of the large population of systems in the domain of nature and humans exhibit cycling, a new dimension of order is possible over and above that of synchronized inputs and outputs.

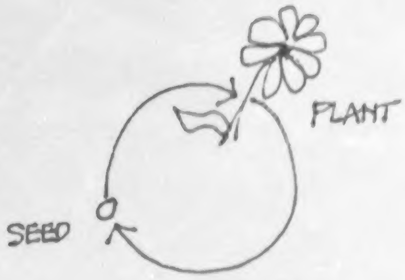
Any discussion of cyclical movement requires a consideration of time or periodicity. The time period of a cycle, or the rate of cycling, is an important aspect in determining its holistic impact on other systems.

Two kinds of cycles will be discussed:

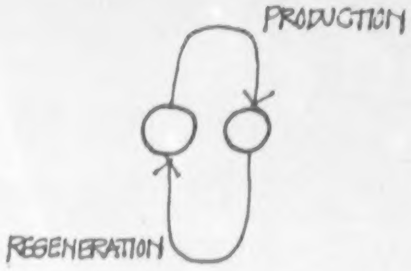
- Life Cycles
- Periodic Cycles

Both types of cycles have as a fundamental organizing concept "periodicity of the process." Also, both are based on the concept of ordered "sequences" of events.

A life cycle focuses on the origins, growth, and decay of a system, with accompanying return of its subsystems to the environment.

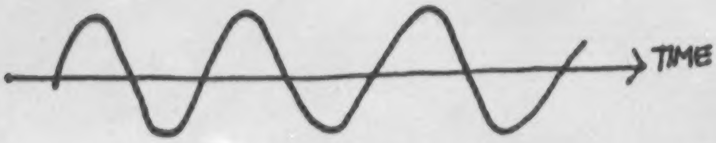


LIFE CYCLE



LIFE CYCLE

Periodic cycling, however, focuses on the continuous transitions of a system through time-dependent state changes, followed by return to the original state and then serial repetition of the state changes.



PERIODIC CYCLES

Thus, the two types of cycling differ in that an entity in a life cycle does not return to its birth state after death. The very same organism does not repeat this cycle endlessly. Life cycles involve repetition of form: all living (even non-living) entities of the same class exhibit the same phases (form) in their life cycle--birth, maturation, death, dissolution.

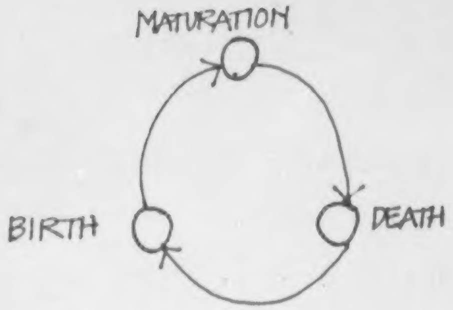
In a periodic cycle, however, the same states are repeated endlessly by the same individual. An entity does return to its "birth" state. It does not, however, return its subsystems to the environment as is the case in life cycles.

Any kind of cycling is a stability-related process. Because of the nature of cycling (its potential for re-cycling components of the system), there is a close correspondence between inputs and outputs. This correspondence introduces a magnitude of order, organization, and stability to the system and its relationship to its environment. Input not only goes through the ordered "steps" of the cycle on the way to becoming output, but it is also ordered prior to becoming new input for the system.

The aspect of stability is derivable from probablistic considerations. In a larger environment of random flows, a cyclic fluctuation appears as order. Each segment of the cycle is completely predictable. Each segment of a cycle is identical to its corresponding segment on the next cycle. Each segment of one cycle is determined by, and is related in the same way, to its neighbors as is its corresponding segment in the next cycle. This aspect of cycling is common to both life cycle (biological/sociological systems) and periodicity cycle (physical systems) types.

a. Life Cycles

The life cycles of cells and of organisms are well known. After death, their various constituents are degraded to simple forms, and are thus available for formation of new organisms. Life cycles are a key pattern of systems of all kinds, from the biological to the astronomical.



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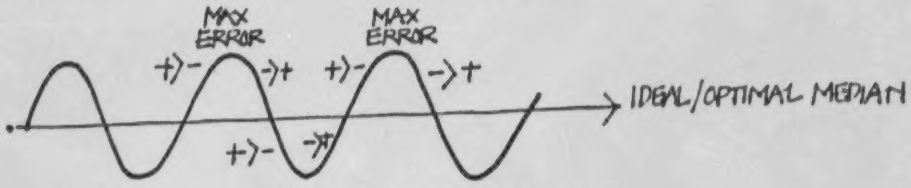
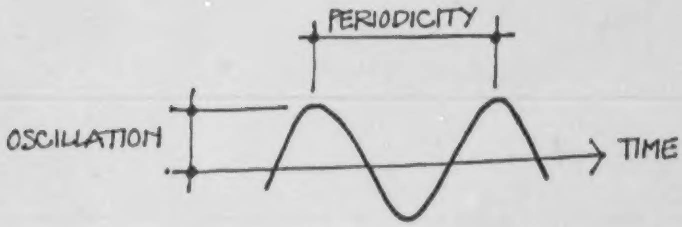
b. Periodic Cycles

Periodic cycles are of two types: pure oscillations in linear systems, and limit cycles in non-linear systems. Either type of periodic cycle requires waves of input needs and yields waves of output production in reliably predictable rhythmic flows.



OSCILLATIONS

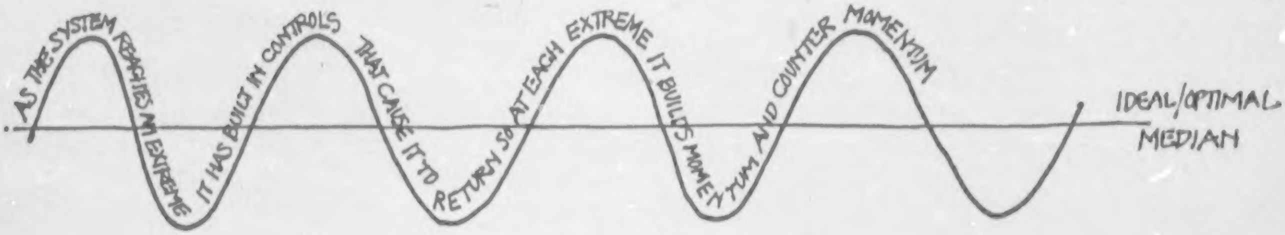
Oscillations are exactly repetitive fluctuations in states of a system around an optimal median behavior, caused by coupled negative and positive feedback signals as shown below.



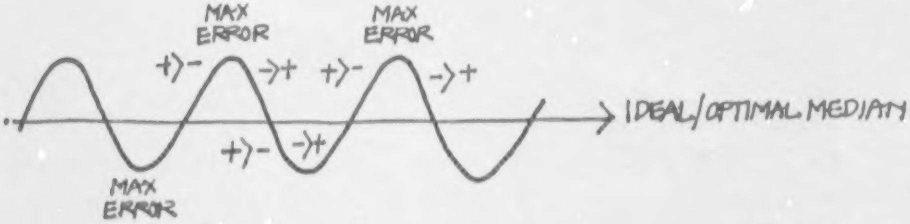
LIMIT CYCLE

Limit cycles are periodic or rhythmic flunctuations in states of a system. These cycles would dissipate if not constantly supplied by energy, and consequently are restricted in their ranges of variance (limits). The feature of constantly required input of energy indicates that limit cycles should be found chiefly in open systems.

Cycling in systems is conservation of energy. The fact that each segment and its relationship is repeated in each cycle and predetermined indicates that less energy may be required to accomplish the transformations found in the cycle. The step-by-step gradation of pre-set segments is probably selected by the environment so the system requires less energy to surpass the thresholds between each step.


AS THE SYSTEM REACHES AN EXTREME IT HAS BUILT IN CONTROLS THAT CAUSE IT TO RETURN SO AT EACH EXTREME IT BUILDS MOMENTUM AND COUNTER MOMENTUM
IDEAL/OPTIMAL MEDIAN

These momenti keep doing the endlessly repeating behavior at less energy cost than such activity would normally cost. Each derivation actually "seeds" the response deviation, which "seeds" the response deviation, ad infinitum.


MAX ERROR
MAX ERROR
+)-
->+
+)-
->+
+)-
->+
IDEAL/OPTIMAL MEDIAN
MAX ERROR

The "extremes" drive the oscillation around the ideal median of behavior because of the coupled + and - feedback control systems involved.

This leads to two new insights. First, the coupled nature of positive and negative feedback modifies simpler unidirectional patterns. Such unidirectional patterns could not, in any case, continue forever. Resources would be soon exhausted and increasing or decreasing trends would soon cause the system to reach the limits of its environment. This would lead to complete systems death.

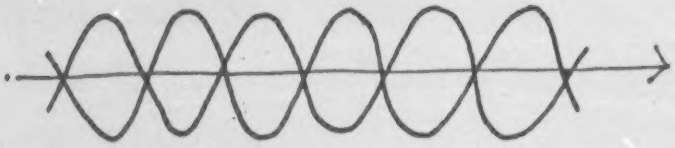
Thus, immature biological and ecological systems, for example, survive best that oscillate and show cycling. The constant flux in the cycle also helps it utilize, process, and transform resources at hand more efficiently and keeps the cycling system in a posture of dynamic flexibility of obvious advantage to survival in a changing environment.

The oscillations about the median we have just described keep the system in flux, ever seeking, but never quite achieving stability. However, any system with cycling is centrally quite stable; the "searching" instability from cycling is only marginal. So, it fills the bill for systems evolution and adaptation. Thus, cycling is a form of planned instability conducive to adaptation.

c. Cycling Terminology

The frequency, the periodicity, and other parameters of the cycles themselves can be in synchrony or dissynchrony. This is harmony and order between systems, rather than components of systems.

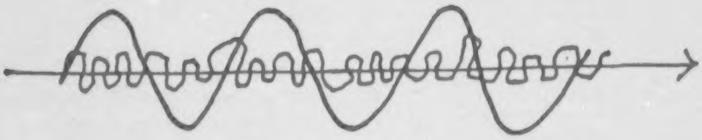
If the cycles of a homogeneous or heterogeneous population of entities are in synchrony according to important shared environmental parameters, then these entities are said to be in cyclic consonance.



CONSONANCE

This enables reinforcement between different systems and creates environments favoring higher level, mutually supportive organizations. Examples are common in mutually cooperative biological and sociological systems.

If the cycles of a homogeneous/heterogeneous population of entities are in dissynchrony relative to important shared parameters of their environments, the entities are in cyclic dissonance. Wave interference is an example. Biological and sociological systems do not often produce examples of cyclic dissonance, especially disharmony with geological and astronomical cycles. To be in disharmony with the cycle that supports you is to be dead.

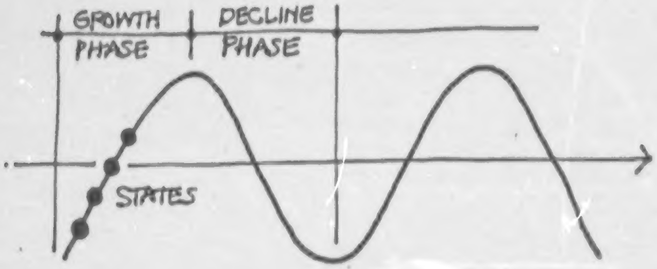


DISSONANCE

To further describe cycles and cycling, we can refer to their states, phases, and modes.

A cycle can be described by the succession of states of a process. The cycle, being dynamic, is never in true equilibrium, but the state can be identified as being in "local" equilibrium by focusing on one instant of time.

The phase of a system performing cyclically is studied by enlarging the time focus. These phases may be categorized as "growth," "decline," "transition," etc.



Modes may be considered as cycles within cycles, such as a reproductive mode within a life cycle. The use of the term mode is also frequently associated with a control function, such as a switch to change a "cooling mode" to a "heating mode."

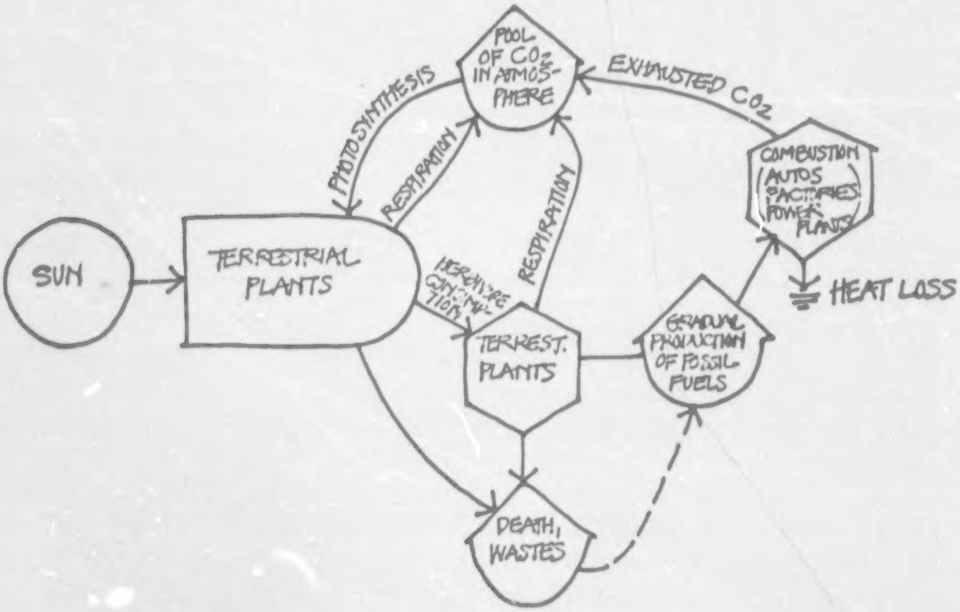
EXAMPLES OF CYCLES

ASTRONOMICAL SYSTEMS: Rotations and revolutions of planets, stars, double stars, and galaxies represent a very simple form of cycling. Nuclear processes such as the proton-proton and the carbon cycle converting hydrogen to helium in stellar interiors are examples of cycles.

PHYSICAL/CHEMICAL SYSTEMS: In a meteorological system, it is possible to illustrate with some self-consistency how tidal oscillations come about and thus how the dynamics of weather may begin.

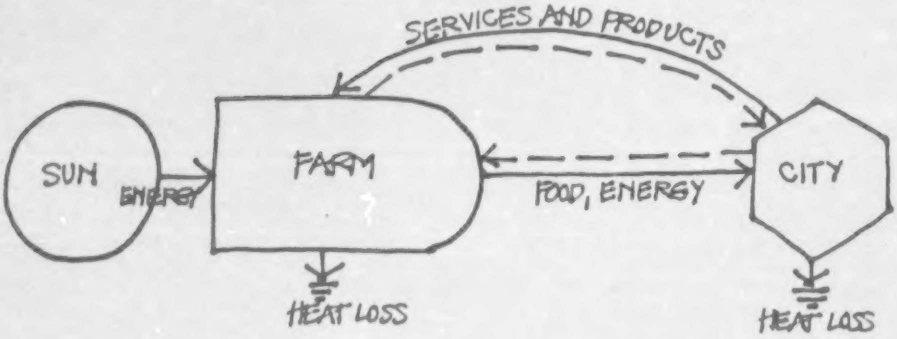
BIOLOGICAL/ECOLOGICAL SYSTEMS: A flow of energy from the sun constantly enters and passes through the earth's ecosystems. Ecosystems have no similar extraterrestrial source of carbon, nitrogen, water, phosphorus, potassium, oxygen, and sulfur, and many other substances that are necessary for life. These key substances must be continually recycled between the living and nonliving components of ecosystems if the ecosystem is to persist. These biogeochemical cycles are a critical aspect of ecosystem structure process.

Carbon is a basic constituent of all living things and in a sense life on earth is based on carbon. This fundamental carbon cycle is shown below:


POOL OF CO2 IN ATMOSPHERE
EXHAUSTED CO2
PHOTOSYNTHESIS
RESPIRATION
RESPIRATION
COMBUSTION AUTOS FACTORIES POWER PLANTS
SUN
TERRESTRIAL PLANTS
HERBIVORE CONSUMPTION
HEAT LOSS
TERREST. PLANTS
GRADUAL PRODUCTION OF FOSSIL FUELS
DEATH, WASTES

ECONOMICS SYSTEMS: Everyone is familiar with money and appreciates its significance. Few, however, understand the money cycle, and how it is linked to energy flow. Money flows in circles, but energy flows through a system. "The flow of energy makes possible the circulation of money, and the manipulation of money can control the flow of energy."[19]

The figure below shows the cycle of money for a simple agricultural economy:



"To understand the relationship of money and energy, one must recognize that money is a cycle which does not turn unless material cycles are turning and energy is flowing. If energy becomes less available, the system must turn more slowly."[20]

Periodic cycling between inflation and depression has been a constant worry of economists. The recent economic crisis was an unusual combination of inflation and depression. Economists are now worried that too rapid economic recovery may trigger another cycle of inflation.

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[19] Odum and Odum, Energy Basis, p. 49.

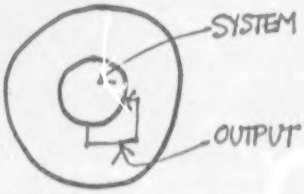
[20] Ibid, p. 52.

URBAN SYSTEMS: Cycling can be observed in road systems in the following ways: 1) vehicles, such as buses, may cycle through the same route in the system on a regular basis; and 2) traffic flows may have recycling effects such as morning and evening rush hours on a daily basis.

SOCIAL SYSTEMS: Power groups and special interests often cycle through positions of dominance in political systems. Even the cycling of attitudes, such as "from conservative to liberal to conservative," is common in political systems.

4. FEEDBACK

Feedback is an energy flow, a signal, that reverts back to the source of an action. It involves the alteration of what a system produces when a portion of its output returns to influence the system's behavior.

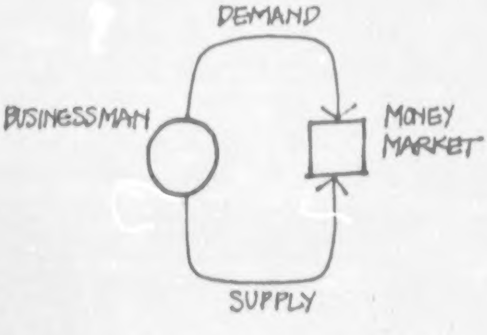


FEEDBACK

Examples of feedback are found throughout all systems of humans and nature. An example of feedback in economic systems is the following:

> A change in expectations of businesspersons feeds back into the money market and causes a shift in the demand for money, which in turn affects the interest rate and thus causes the entire money market to adjust to a new equilibrium.

The system has adjusted to disruptions which disturbed its equilibrium. There is a closed loop of energy flow between the businessperson and the money market. This path of energy flow is called a feedback loop.



FEEDBACK LOOP

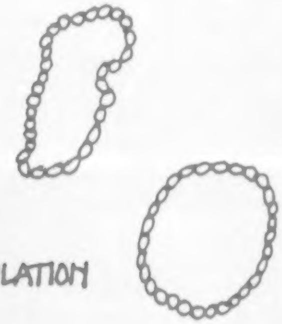
In a learning system a person (teacher) gives a presentation to students and receives information back from the students concerning the presentation. This feedback is used by the teacher to modify the presentation. This behavior-reinforcement-behavior cycle is also a feedback loop.

Thus, feedback promotes change in the system--it is somewhat altered or modified as a result of the feedback. In this way, feedback is a basic mechanism for encouraging the growth or the control of a system.

a. Static Regulation

Regulation is a word for systems control. It is most often mediated by a feedback mechanism. Regulation characterized as "static" is found in mechanical and physical nonliving systems (as well as in the physical and mechanical subsystems of living systems). "Static" implies built-in compensation to keep the system at equilibrium; static regulation always concerns the "limits" of a system.

A diagrammatic representation of static regulation would be the following: imagine a circular chain, loose, so that there is room for expansion of the circle it forms.



STATIC REGULATION

Static regulation defines the limit of expansion of this system (pulling the chain tight) as the largest circle that can be formed, still maintaining the integrity of the structure.

Other examples of static regulation include:

- a fuse that "regulates" the flow of electricity by breaking when the amperage becomes too great;
- a screen filter that allows only particles of a certain size to pass through it;
- a "blow-out" valve which is passive as long as pressure remains within limits, but "blows out" when pressure gets high enough to endanger the system.

Static equilibrium is a control mechanism; it prevents "overload" of a system.

b. Dynamic Regulation

Dynamic regulation is more typical of living systems than it is of mechanical and physical parts of natural systems. In dynamic regulation, two switch states (an "on" and an "off" state) are arranged so that the system switches from one state to the other when the regulated parameter drops to a lower limit (e.g., a thermostat).

Another example of dynamic regulation is a toilet tank float that turns the flow on when the tank level is too low and turns the water off when the water is high enough.

In feedback regulation (or control), an error signal is produced between the existing state of a system and the desired regulated level. This error signal is operationally acted upon in a way that will influence the regulated variable so as to reduce the error.

In the case of either static or dynamic regulation in the examples above, note that the regulation existed to stablize the system. The chain, the temperature in a room controlled by a thermostat, the toilet tank, all would exceed their limits and cease to exist as a system without the regulation. So their function is to maintain "systemness."

Note also that the differences between static and dynamic regulation denote a difference between types of feedback mechanisms. In the static case, the structure of the parts of the system mediates the change. In the dynamic case, the flow of things in the system mediates the change. The difference between static and dynamic regulation also focuses our attention of a fundamental distinction between types of systems--physical-mechanical versus living systems.

Each of the distinctions above can clarify a part of our relationship to the environment. Nature has taken billions of years eliminating systems that had insufficient regulation of either kind to control them within the limits of the surrounding systems.

Human-designed systems have not all achieved appropriate regulation. If one subsystem exceeded the demands allowed it by its place in the whole due to faulty regulation, then the cooperation among the subsystems would be disrupted. Either the whole or the subsystem would be destroyed. A person is but a subsystem in his or her environment. We must also follow the rules of regulation in the design of our systems!

c. Negative Feedback

Negative feedback opposes the direction of flow from a system; it is non-reinforcing or corrective. Negative feedback diminishes the product. Thus, it is an effective control mechanism keeping the system within the limits of its environment. It provides stability, but it can limit a system to no-growth.

d. Positive Feedback

On the other hand, positive feedback reinforces the main driving force of the system and encourages growth. For example, power generation and population growth constitute a positive feedback loop, in which the generation of additional power makes possible additional human population growth. And then the additional human population creates a need for still more power generation.

But such growth cannot occur indefinitely. Thus, natural systems often have both types of feedback to regulate system size.

Positive feedback without negative leads rapidly to disaster. Negative feedback alone does not cause disaster, but it can limit a system to no growth. Many of our human-designed systems have positive feedback (growth of our population, technology, energy systems) with poorly developed, or non-existent negative feedback. It is no wonder they suffer from this imbalance. Nature took billions of years to evolve balanced systems. Observing these feedback characteristics, we can apply them to better maintain our own life support systems, and to keep a balance between our human-designed systems and the natural systems on which they depend.

e. Goal-Seeking Feedback

Feedback, positive or negative, which results in adjustive responses necessary to reach a preset goal is called goal-seeking feedback. The system is engaging in a selective process; it incorporates feedback as it relates to achieving the preset goal.

There is some debate among scientists as to which kinds of systems exhibit goal-seeking behavior. Most scientists are rigorously against ascribing goal-seeking behavior to any systems except the higher organisms.

Natural systems may be so well-ordered, so cooperative and complementary to each other that it seems they must serve a goal--and therefore are goal-seeking. But scientists contend that they are so well-ordered because of billions of years of patient, random, trial-and-error processes involving elimination of all systems that are not "fit."

People are often goal-seeking. But their goals are not always set with clear consideration of all the limits of the environmental systems around them. They are very oriented to short-term goals, to the detriment of important long-term goal-seeking. This conflict indicates one of the important insights this concept yields for improving human-environment relationships.

People are able to adjust their output, or responses, to reach a preset goal. At times it is very necessary to also adjust the goal itself.

f. Goal-Changing Feedback

If feedback results in self-modifying responses and leads to alterations in preset goals of the system, it is goal-changing feedback. The preset goals are altered as a result of this type of feedback.

This ability to change goals is a very important factor in our relationship with the natural systems of our environment.

EXAMPLES OF FEEDBACK

PHYSICAL/CHEMICAL SYSTEMS: Muscular action of heart and aorta sustains the blood pressure in the veins. Stretch receptors in the walls of the aorta act as transducers. It is a simple information-processing system having negative feedback. If a person suddenly changes from lying down to standing up, the pressure receptors activate the heart's motor center via negative feedback. The falling blood pressure leads to increased activity of the heart. There is some delay (about 10 seconds) but then the drop in pressure is checked and brought up.

BIOLOGICAL SYSTEMS: Feedback control is essential to the homeostasis of biological organisms. In mammals, the body core temperature is maintained nearly constant in spite of wide variations in external temperature and in internal heat production. If body temperature falls, heat production is increased, mainly through involuntary muscle contractions (shivering). If an excessive heat load is incurred, cooling and dissipation of the heat is achieved through sweating or panting. Both the heating and the cooling of the body are regulated by negative feedback systems centered in the hypothalamus of the brain.

ECOLOGICAL SYSTEMS: Populations of organisms may also maintain a homeostasis of dynamic equilibrium through feedback mechanisms. Sheep blowfly populations remain at a constant level while sustaining up to 99 percent removal of adults. This is accomplished via a compensating mortality process whereby, as exploitation increases, mortality decreases and vice versa.

Complex territorial behaviors are commonplace among birds and mammals and serve to adapt population size and reproductive rates to levels of food availability. When food is abundant, breeding territories are small and the amount of reproduction per unit area is large. When food is scarce, breeding territories are large and the amount of reproduction per unit area may be very small. This feedback between food availability and population growth prevents the overexploitation of renewable resources.

ECONOMICS SYSTEMS: The classic economic "law of supply and demand" is an example of feedback. Demand for goods can stimulate the development of new supplies. An abundance of supplies with good advertising usually creates demands. The availability of labor and resources dynamically regulates production in economic systems. Profits are typically a mechanism of positive feedback--reinvested to manufacture new products. Advertising is a positive feedback used to stimulate consumption.

SOCIAL SYSTEMS: The education system depends upon feedbacks for discipline and motivation. Grades on a report card represent symbolic feedback encouraging scholarship and embarrassing failure. Teachers verbally praise good classroom performance and scold misbehavior. More rigid social contracts in the form of written law act as negative feedback for what is viewed as socially destructive or misanthropic behavior.

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5. EQUILIBRIUM

The concept of equilibrium is essential to the very existence of a system. It is important because it refers to the ability of a system to maintain its structurprocess despite changes in the environment.

The word refers to the fact that despite external perturbations, the former state of a system "is equal to" or "the same as" the latter state of the system.

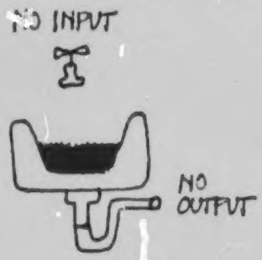
Equilibrium is closely allied to the concept of feedback: negative and positive inputs to the system need to be balanced to prevent a no-growth or a runaway growth situation. Regulators, static or dynamic, help keep systems in equilibrium.

In a discussion of equilibrium in systems, this section will describe two kinds of equilibria, static and dynamic. It will also define the conditions of stability and instability in systems.

a. Static Equilibrium

Static equilibrium results when there is no change in the specified parameter or state under observation because there is no input/output activity. The system is non-dynamic; states of the system are constantly equal.

A bathtub filled with water is in a static state of equilibrium. The level in the bathtub does not change if the faucet is off (no input) and the drain is plugged (no output).



STATIC EQUILIBRIUM

Of course, if a long enough time period were granted, evaporation would change the water level. We are ignoring long-term effects to simplify this example. But this simplification in fact provides us with a lesson about static equilibrium--it is quite dependent on its environment and is successful more often in the short-term rather than the long-term.

Environments often change. Systems with static equilibrium have no dynamic mechanisms for return to equilibrium. In many cases of equilibrium bodies are at rest. Their equilibrium is one of having reached the lowest energy state, not one of active maintenance/achievement of an equilibrium through constant adjustments of couplings between its subsystems.

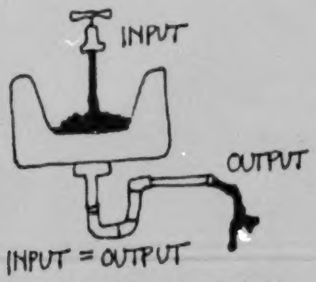
b. Dynamic Equilibrium

The result of a dynamic equilibrium is the same as that of a static equilibrium--no change in the parameter or state under observation. However, the mechanics for achieving the equilibrium are dramatically opposite to those for achieving static equilibrium.

The unchanging condition in a dynamic equilibrium results from constant adjustments of internal couplings between subsystems despite shifts in input/output from the environment. The system in this case is very active, not passive, in its relations with the environment.

Dynamic equilibria are found in open systems that receive inputs from their environment and return outputs to the environment. The constant flow through (throughput) of materials, energy and/or information gives the equilibria its dynamic character.

The simplest dynamic equilibrium in a system would be one in which equal flows of input and output allow for maintenance of the constant condition of a parameter or a state. For an example we could again look at the constant water level in a bathtub achieved by adjusting the water flow from the faucet (input) exactly to the loss of water through the drain (output). The water level remains the same although there is a constant and dynamic flow of water through the system.



DYNAMIC EQUILIBRIUM

Another example of dynamic equilibrium would be the constant number of individuals in populations achieved when the birthrate and the death rate balance each other.

Equilibria need not always be of the simple variety achieved by equal input and output flows. Many dynamic equilibria are achieved despite scarcity of input or overflow of input by adjustments in the linkages between the subsystems of the systems. This type of equilibrium is the result of long-term evolution.

The term steady state is a more general word than static or dynamic equilibria. It is more descriptive of the state achieved than the mechanism by which the state is achieved. Steady state can be achieved through either static or dynamic equilibrium, and is therefore described as either a static or a dynamic steady state. Simple illustrations of static and dynamic state would be:

STATIC:
- A light socket, unused.
- A water storage tank.

DYNAMIC:
- A light socket that settles down to a steady state of a continuous 60 cycles after the slight transient fluctuations stimulated by plugging into it settle down.
- A river with an unchanging water level.

c. Stability

The concept of stability is one of the most important concepts in systems theory. A "stable" structurprocess is capable of maintaining its identity and integrity by flexible mechanism through the longest period of time relative to other entities on its level of the hierarchy.

Stability, not overt growth, appears to be the most successful strategy of natural systems. This speaks directly to a major present-day issue concerning human-environment interactions--growth or no growth. It neutralizes the issue by advising mankind that systems and evolutionary heuristics successful over the eon have focused on balance rather than on growth alone. Oddly enough, the very best balance/stability arrives from not having too much stability. It is the dynamic between stability and some instability that appears to give the longest term balance and the success of efficiency and survival.

Stability is a relative term. A system achieves only the mechanisms necessary to keep it in balance relative to the limits of stress it experiences in its environment.

At certain levels of complexity (in number of parts) a system cannot maintain its stability; at all levels below that boundary, a system is capable of returning to equilibrium or original position after having been displaced.

> Example: studies of solar masses show that at a certain point of complexity of units, a nuclear fusion occurs and maintains itself or becomes the star. At other levels it may become a black hole with no self-generating capacity, or a self-destructive super-nova of maximum instability.

One final reemphasis is needed. Stability through equilibrium should not be confused with lack of change. The most superior stability is one that is achieved by dynamic equilibria that are consistent with all knowable dynamic equilibria of surrounding environmental systems.

A kind of very slow stabilization where the system appears to be undergoing no recognizable change, is metastability. Actually, change is always involved, but it is a unidirectional process of very slow change. The change is so methodical, and relatively irreversible in its progress that it results in great systems insensitivity to perturbation.

Because this type of unidirectional change is so unusual in natural systems, the term is most often applied to simple systems phenomena in human-designed physical systems.

> Example: Concrete appears to be unchanging, but actually it goes through a continual curing process that is irreversible in the entropic sense. After hardening, concrete is relatively metastable for this reason.

Government bureaucracies are also material for case studies in metastability, since they are characterized by long, slow, unidirectional growth, accretion, and "setting" similar to concrete. Achieving the maximum good for the maximum number of government personnel on the lowest levels often results in metastability on the higher levels. The lowest level subunits become intractable as no free usable energy exists to cause change from the bottom up.

d. Instability

An unstable/instable system is one that is easily upset or unbalanced to the degree that it loses its identity. It is changeable, variable, and easily decomposed.

Troncale (1972) draws a distinction between "central" and "peripheral" instability. "Central" instability involves inability of subsystem linkages to maintain that degree of coupledness that will maintain the integrity of the system. Since this type of instability is internal to the system, it is termed "central."[21]

When we say "subsystems are unable to maintain their linkage" we are really saying that on a probabilistic basis most of these systems will disintegrate. In stability/instability determinations, time and probability are always the judges.

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[21] Len Troncale, Models for Training Environmental Education Teachers Utilizing the General Systems Paradigm, DHEW Contract No. 300-75-0224.

"Peripheral" instability refers to linkages external to the system, between the subject system and other systems. These linkages are capable of continous formation and breakage--they introduce variability, flexibility, and exploration to systems complexification.

As pointed out in the discussion of stability, the best balance arises from not having too much stability. Instability is not a threat to stability; rather, it is a balance for too much stability.

Like structurprocess, or positive and negative feedback, stability/instability is a union of extremes important to wholeness.

e. Transtemporal Stability

The concept of stability is a time-related one. The entities of a system that are linked as its subsystems have to last together long enough to be perceived by people or to have an influence on the probabilistic distribution of other systems before they can be designated a system.

Transtemporal stability is a recognition of how long (trans = across, temporal = time) a system remains stable. By its very nature, this concept is dependent upon relativity and probability. It is dependent on probability because the natural stabilities of systems are dependent upon the subsystems that make up the system. The subsystems themselves must have a certain order of magnitude of stability and a certain frequency of occurence to function as subsystems.

The concept of transtemporal stability needs to be considered in two dimensions--that of structure and process. It is most easily seen as a description of a stable, long-term structure dependent on surrounding inputs.

For example, a plant is a stable assembly of leaves, stems, and roots that uses inputs like solar radiation, nutrients, and processes like photosynthesis to sustain itself. The structure is tangible and humans can readily appreciate its life and death cycle. This is visible transtemporal stability of structure.

But, less easily visible examples of transtemporal stability also exist. Transtemporal stability is an invisible process, not a structure, and can be exemplified by radiation emitted by a decaying element. Radiation of some substances may last 250,000 years. Yet people place high concentrations of such a stable process in lead cannisters that last only 40 years. Even the salt mines in which these cannisters filled with radioactive materials are placed may not last 250,000 years. The geological salt beds that are not dry, may be lake beds if another ice age occurs. This could happen in another 25,000 years.

The transtemporal stabilites of systems are best characterized not by the dynamics on their own level alone, as has often been the case, but on the levels preceding their origin, and by careful study of the probabilites of each interaction on the preceding levels. The system that is transtemporally stable is such only in relation to its local/regional environment.

EXAMPLES OF EQUILIBRIUM

ASTRONOMICAL SYSTEMS: A star is a system in equilibrium. The gas and radiation pressures thrusting radially outward are in equilibrium with the gravitational pull inward.

PHYSICAL/CHEMICAL SYSTEMS: The safe yield of ground water may be defined as the amount of water that may be drawn without permanently altering the level of the ground water, thereby maintaining a steady state or equilibrium.

Drainage is an example of a natural constraint in which equilibrium is maintained through a balance of flows. For example, an impoundment will dam water, causing it to collect (a new equilibrium may be reached). A diversion may direct water away or onto a site, also disrupting equilibrium.

When the pendulum of a grandfather clock is down, it is in equilibrium. If the pendulum is moved just slightly, it will move in the reverse direction just past its original equilibrium point, but it will die out to nothing. This is a limit cycle (see Cycles). If you move the pendulum past its threshold, it will create an unstable limit cycle.

BIOLOGICAL/ECOLOGICAL SYSTEMS: Equilibrium is related to the chain of populations. A certain amount of vegetative area will support a certain number of predators. Disruption of the energy flow by taking away or increasing any component of the system can have effect on other components of the system, disrupting the previously existing equilibrium. For example, if all predators such as coyotes or carnivorous birds were killed in an area, equilibrium would be lost and there would probably be a population explosion of rodents.

Dynamic equilibrium of population size is the predominant pattern in natural biological communities. Individuals die and are born, but over the years populations tend to remain at the same general level. This equilibrium is maintained by a wide variety of density dependent feedbacks. Survivorship, growth rates, fecundity, and longevity may all be affected by population density. If there were no density dependent feedback, then each population would either go extinct or grow infinitely.

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ECONOMIC SYSTEMS; Equilibrium occurs in the market when the quantity of any good or service supplied equals the quantity demanded. The economy is considered to be in equilibrium when aggregate demand (total demand for all goods and services) equals aggreagate supply (total supply of all goods and services) in a given period of time.

Profits and increasing production are positively correlated in the U.S. economy such that the system is committed to economic growth. However, because energy and material resources are ultimately limited, and because of environmental intolerance of endless consumption, economic growth cannot continue forever. An equilibrium economy is inevitable. This equilibrium will be transgressive in that new technology and efficiencies may increase that equilibrium of production.

SOCIAL SYSTEMS: Social systems often tend to encourage conformity on the part of individual behavior. The concept of normal versus abnormal (or deviant) behavior reflects the ideal of some equilibrium social behavior. Nervous breakdowns and social rioting are examples of loss of social equilibrium. Social stability is usually defined as dependent on behavioral equilibrium or social status quo.

6. HIERARCHY

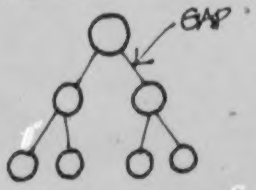
In any field, hierarchies help to simplify the complexity of the world around us by providing a transdisciplinary, isomorphic organization. Examination of the features of a hierarchy will provide insights that are helpful in recognizing hierarchies, understanding their characteristics, and noting their significance to the structur-process of systems in general, and to human-environmental systems as a special case.

Hierarchy is more than simply the principle of gradation. A hierarchical system does have a graded order--some organization, usually pyramidal in nature, of lesser or greater degree. But a "principle of gradation" is only part of the pattern. To use gradation as the only diagnostic feature of hierarchies would allow organizations that are clearly not hierarchical to be classified as hierarchies.

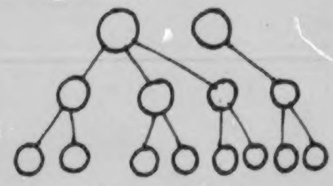
a. Characteristics of Hierarchies

In an interdisciplinary conference sponsored by the Smithsonian Institution on Information and Control Processes in Living Systems, the participants attempted to list a number of features they thought were characteristic of hierarchies. There were:

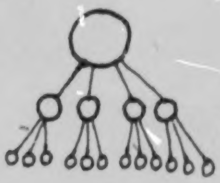
(1) Exhibiting gaps between distinct levels.



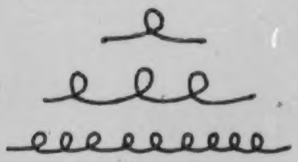
(2) Showing pyramiding numbers, such that entities are present in much larger numbers on lower levels and fewer, more constrained numbers on higher levels.



(3) Exhibiting pyramiding masses, such that lower levels are smaller aggregates of matter than are found on higher levels.



(4) Showing time-constant changes between levels, such that typical interactions on lower levels are characterized as very rapid relative to those occurring on higher levels.

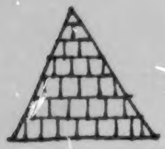


(5) Exhibiting a change in control priorities, such that lower levels control upper levels only insofar as they constrained possibilities and operated on all members of the higher levels. Clearly designated groups of lower levels, however, are controlled by priority interrupt from above.

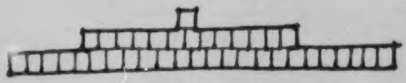
Some of the types of hierarchies than can be distinguished are:

(1) Natural and Man-Made Hierarchies

One difference between a natural and man-made system is that the gaps in a natural hierarchy are usually steeper and more equally spaced than those of a manmade system where the ratio of the number of levels to the span is small (i.e., a flat hierarchy).



NATURAL STEEP HIERARCHY



MAN-MADE FLAT HIERARCHY

(2) Structure-Based, Function-Based Hierarchies

A structural hierarchical example would be the government (formal) (ideal). If you examine a government bureaucracy, you can actually cite a structure of bureaus. The most immediately recognizable quality is the static, authority-oriented form.

It is interesting that a functional hierarchical example could be taken from the same phenomenon. Rarely have people developed an understanding of how hierarchical bureau interact, but the interaction is very real and just as important as the more easily perceived structure.

Actually, hierarchies are always both structure and process united into structureprocess. "In the last resort, structure (i.e., order of parts) and function (order of processes) may be the very same thing: in the biological world structures are the expression of a flow of processes."[22]

(3) Control Hierarchies

Control hierarchies are a form of criteria for defining levels in a hierarchy which can be used for "command" or "control" of one level over another. Such control functions, or ordering principles, can clearly be seen in biological systems, as well as in behavioral and societal systems.

It is important to realize that hierarchies of all kinds have common properties irrespective of their specific content. A discipline, or environmental problem area, redefined in terms of hierarchies may suddenly yield new understanding. For example, economic systems have many hierarchical manifestations. Yet, the term is rarely used in this field.

The human-environment interface could benefit simply from application of many of the principles of hierarchical dynamics.

To help discover the pattern of hierarchy in real life situations and to prescribe how those situations could be improved, the following aspects of hierarchies will be discussed:

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[22] von Bertalanffy, Trends, p. 27.

- Levels
- Incremental Trends
- Horizonal Proliferation and Inter-Level Vertical Evolution
- Exclusion Principle
- Transgressive Attribution

No one of these subpatterns can be used alone to distinguish what is from what is not a hierarchy. They must be applied as a set, and a judgment made on that basis.

Fixed views of what the "natural" hierarchy is should be avoided. Such fixations become errors of the future. One should recognize that there is no rigid definition of hierarchy. It is important to achieve a strong feel or impression for what a hierarchy pattern contains. But flexibility of judgment is the goal. And, form should not overshadow process.

b. Levels

Entities in natural and human-designed systems tend to cluster into groupings that we call levels; between that and the next grouping in the hierarchy there is a gap. The gaps and the levels arise spontaneously from the nature of the entities themselves, and are not dependent on human bias or interpretation.

The key to understanding hierarchies is to find a "filter" for human perception that allows us or helps us to see the levels that nature and probability provide, and to be aware of those cases where supposed hierarchies are defined in the more arbitrary terms of human language. The question of recognizing hierarchies with precision comes down to what is and what is not a level.

How may a level of hierarchy be non-arbitrarily defined? A parity/difference test is only as good as the parameters used. The simplest method of detecting clusters and levels would be to measure such key parameter "filters" as:

- Size
- Numbers
- Interaction Energies
- Interaction Times
- Interaction Distances
- Cycling Time
- Generation Time
- Generation Energies

And further, to see if in all cases the levels resolved are the same. For example, in a simple food chain of bugs-rodents-hawk the parameter filters are applied as follows:

SIZE:	small bugs, larger rodents, very large hawk.
NUMBERS:	many bugs, few rodents, one hawk.
INTERACTION ENERGIES:	rodent spends less energy per bug than hawk spends per rodent.
INTERACTION TIMES:	rodent spends less time hunting and eating bug than hawk spends on rodent.
INTERACTION DISTANCE;	much shorter between rodent and bug than airborn hawk and terrestrial rodent.
CYCLING TIME:	rodent digests bugs faster (and hunts again sooner) than the hawk that feeds on rodents.
GENERATION TIME:	bugs regenerate faster than rodents who regenerate faster than hawks.
GENERATION ENERGIES:	bugs spend less energy to regenerate than do rodents or hawks.

This simple chain exhibits consistent clustering of levels: measuring the magnitude of the elements by any of the key parameters achieves the same resolution.

c. Incremental Trends

Tied very closely with the concept of the nature of levels would be the incremental trends observed between the defined levels. We call the trends "incremental" because, the magnitudes of parameter measurements across a succession of levels change by distinct jumps.

The same key parameters used to detect levels can be used to designate the increments of the hierarchy. For example, increasing size as an incremental trend results from the formation of complexes--from the bonding together of subunits. An example is the family unit in the neighborhood, which is part of the city/county system, etc.

Decreasing numbers as a trend can be illustrated by the food chain of bioplankton (many)-zoo plankton (fewer)-little fish (few)-big fish (one or two).

Decreasing interaction energies as an incremental trend is evident in the gradation from strong to weak in the binding force as follows: the force binding an atomic nucleus together far exceeds the force binding two cells together, which exceeds the demonstrable force binding societal units together.

Interaction times clearly show an increasing trend from the microscopic to the macroscopic scale. For example, interaction times of atoms are on the order of 10-13 seconds, while interaction

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times of the subatomic particles of which the atoms are composed are orders of magnitude less. In the other direction on the hierarchy, as the size of the molecule increases to macro-molecules, the time required for interaction increases.

Also, as the size of the subunit interacting increases, the distance over which the bonding force must act also increases. For example, interatomic binding acts over distances of 0.5 to 2.0 angstroms. Macromolecular distances of interaction range widely from 10 to 250 angstroms, while intercellular distances of interaction may have to act over 1000's of angstroms.

It is interesting to note that sensing "trends" and "levels" in hierarchical situations is related to worldviews. Someone with Worldview One would have a different set of rules and measurements for detecting trends than someone from Worldview Three. Ideally, "levels" and "trends" should be non-humanocentric and empirical.

d. Horizontal Proliferation and Inter-Level Vertical Evolution

Parts becoming wholes has already been discussed. Systems theorists refer to parts of systems by the term "subsystem." Subsystems interact together to make up a system. Systems interact together to make up a supersystem. In this case, the system is acting as a subsystem on the new level. Sub- to super-system interaction forms hierarchies.

If we focus on a level and how its "wholes" arise from the interactions of its "parts" on the preceding level, we can see that there is usually a population of subunits available on the preceding level for interaction.

According to the laws of probability and their bonding potential, these subunits give rise to an amazing spectrum of subunit complexes. All the subunits literally combine in all possible combinations at random. This is called horizontal proliferation, or intra-level variety.

It involves the bonding potentials of subunits as does vertical evolution, which is, however, a different combination--one of inter-level connections.

Intra-level, horizontal proliferation leads to stability only --not to evolution, which requires inter-entity, inter-level complexification.

The random nature of the combinations driving both proliferation and evolution indicates that hierarchies are probablistic, not deterministic. The usual focus on static structure has always given a deterministic aura to hierarchies. They were meant to be the way people felt they should be. But actually, hierarchies that occur in natural systems and those that are most successful in human-designed systems are order induced by probability. This probability gives dynamism and a flexibility to a hierarchy.

e. Exclusion Principle

Interaction on the lower levels of a hierarchy can be effectively ignored when discussing the higher interactions. The distances, time constants, etc. of the interactions at the higher level make direct and active participation of entities on the lower level infeasible.

Hence, once enough complexification levels are passed, the lower constraints are no longer operable (are "excluded") and the new level experiences a type of fresh freedom for random variation unfettered by the past history and commitments of the preceding levels of the hierarchy. This is the "exclusion principle."

When the complementarity of an entity is satified in the nearby space-time continuum, it participates little in evolving higher levels of the hierarchy.

The following examples illustrate interactions among parts of higher level systems that essentially ignore the forces of binding and interaction between their own parts on the lower levels:

- The forces that bind atoms together ignore the forces that bind subatomic particles together in a nucleus of the atom.
- Heads of government are interested in making decisions on their levels of intricacy; they are not interested in the problems on the lowest levels.
- To a salesperson, the color of a car is important; to an assemblyperson, it is unimportant.

f. Transgressive Attribution

Transgressive means to "go beyond." An attribute is a quality or feature considered to be characteristic of an entity. Transgressive attribution means the sudden appearance or emergence of a new characteristic on a new level that far exceeds any characteristic of the previous level. It relates to the incremental trends discussed earlier. As new sizes of complexes appear from subunits, new properties appear that could not be predicted by mere examination of the subunits. This is an example of the saying that "the whole is not equal to the sum of its parts." Systems range from the simplest structurprocess--as, for example, the cell--to the most complex. All along the range, new qualities emerge on each new level. A human being is a system made up of a variety of subsystems. All of them must function together as an entity, and therefore a person represents a structurprocess that, as a whole, is more than the sum of its parts.

EXAMPLES OF HIERARCHY

BIOLOGICAL/ECOLOGICAL SYSTEMS: Nature probabilistically selects system configurations that have the highest survival rates. Through this selection, the pattern of clustered parameters and hierarchy emerges as a supremely successful natural scheme. Food chains with clustered numbers of organisms represent a hierarchy:
***many tiny plankton
 **fewer moderate-sized planktivores (herring)
  *very few large predators (sharks, tuna)

Social ants display an elegant hierarchy that has made them among the most ecologically successful animals in the world. They cluster together in colonies that are so tightly organized that the colonies have been compared to the cities of man. This colonial social clustering usually includes:

- cooperation in the caring of the young
- division of labor (soldier, workers, reproducers, etc.)
- several generations overlap and contribute simultaneously to colony labor
- elaborate alarm, recruitment, and communication systems
- mutual grooming
- oral exchange of food between individuals

Because of their organized clustering, ants are able to collectively ward off predators. excavate deep chambers that moderate environmental fluctuations, and carry as groups food items that a single individual could not handle.

The development of social clusters has contributed to the biological success of species throughout the animal kingdom, including man.

ECONOMIC SYSTEMS: Economic components tend to cluster and create hierarchies. A driving force behind this clustering is the relationship between massive production and efficiency. Thus, multinational corporations or city-sized factories are economic clusters. Economic components may also cluster to form vertical monopolies controlling extraction, processing, production, distribution, and marketing; such is the case for giant oil conglomerates.

SOCIAL SYSTEMS: Hierarchical arrangements are typical of social systems, including non-human animals. Even rodents exhibit dominance hierarchies and hierarchies between groups in their social relationships. Human social systems include hierarchies of class (lackey to aristocrat) as well as hierarchies of organization (family-neighborhood-country).

Families cluster together to form neighborhoods. Neighborhoods agree upon common laws and ordinances and form functioning towns. Towns existing in bounded regions and having compatible political values form political states.

7. SYSTEMIC ENERGY FLOW

No single system is just structure or process, matter or energy. All systems are actually inextricable couplings of both structure and process, matter and energy. We have emphasized this by combining the two words into one--structurprocess.

Since the two aspects of this fundamental dualism are so closely tied, the processes of systems not only transform, but also give rise to the structures of systems, and vice versa.

All energy flow in systems is directional and has velocity. This section will discuss three kinds of energy flows fundamental to understanding systems process:

- Entropy
- Negentropy
- Synergy

a. Entropy

Entropy describes the tendency of systems to run down. It is sometimes used as a synonym for disorder and randomness. In most of the systems with which people identify energy is used to do work--for example, to drive machines, to move one's own legs and arms. These are examples of work in highly ordered systems. Entropy, by contrast, is a measurement of the amount of energy not available to do work in an orderly system.

Entropy has long been recognized by physicists as a consequence of the Second Law of Thermodynamics. This law states that, over cosmological time, and over the whole universe, there is a distinct tendency for more free energy to be made, energy of the kind that is not used for work. The most likely probability in these cases is for the maximum of disorder.

In terms of systems energy flows, the most dominant energy flow is the tendency for the order of systems to decline and decay. Then why is there so much order around us? Because this tendency toward entropy is an energy flow that can be recognized best on a universal, transtemporal scale.

The reliable temperature of mother earth, and the orderly system this temperature allows is totally dependent on the continous supply of energy from the sun. If the sun did not shine, then the earth would rapidly cool off, losing its vital warmth to endless disorganized space. All the orderly systems on earth would die an entropy death. But the sun itself will some day die, having exhausted all of the fuel it had at birth--and so its entropy death will result in the entropy death of earth. Across the universe, stars are continuously dying and therefore the universe is said to be running down, becoming more disordered. That is why the most dominant energy flow is said to be entropic.

Since entropy is synonymous with randomness and disorder, it is considered the opposite of the concept of information, which is organized data for potential meaning. All of our purposive systems depend on information. Whether it be chemical/molecular information in genetics, or language information in social systems, we can expect that there will be some breakdown in the appropriate transfer of the information at every attempt. This breakdown of orderly information transfer is entropy. So one can characterize the fidelity of the transfer of order by measuring the entropy produced.

b. Negentropy

Negentropy describes the tendency of certain systems to create more order in the local environment space/time continuum. This transformation to more order is dependent upon a continuous and generous supply of energy materials and information from sources external to the system.

Negentropic systems are always open systems because of their need for input of energy from outside, their processing of it into organization, and their output of both unused energy and increasing order. Since the energy flows through them they are said to be open systems. As soon as the open system is closed from its energy source or becomes inefficient, it dies. Its tendency toward order has been reversed, to the more universal and irreversible tendency toward disorder.

Since negentropy connotes order, it is in alliance with the concept of information. For information to be what it is, it must be a non-random organization of components meaningful to some receiver. Social systems and biological systems tend away from randomness. They are designed to achieve specific ends. They are purposive in seeking to achieve those ends and are, therefore, called teleological (end-seeking) systems.

c. Synergy

The word synergy was created from two words--"synthesis" and "energy." It refers to two or more systems or processes working so closely together, so cooperatively, that their effects add up to much more than would be expected by mere summation of their individual energies.

The use of the word "synthesis" in the compound word emphasizes that the individual energies work together harmoniously, and are united in promoting a similar direction or achieving a common, shared end. A "synergistic relationship" describes an interaction wherein each party enhances the contribution of the other--each gets out of the partnership more than they put into it. Synergy is negentropic in nature.

The concept of synergy between parts of a system or between systems focuses mostly on the interfaces between the parts of a system or systems. It is a very special optimization of the linkages, interrelationships and input/output ratios.

It is important to recognize that synergy may be either positive or negative in its effects. The central additive feature of synergy does not mean only good effects add up; bad effects can also add up, resulting in more harm when taken together than any one of the bad effects taken alone.

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EXAMPLES OF SYSTEMIC ENERGY FLOW

BIOLOGICAL SYSTEMS: Biological symbiosis or synergy has led to transgressive equilibrium and new hierarchies and levels of complexity. Fungi and algae so elegantly supplement each other that they have formed a new type of organism--the lichen. The origin of the eukaryotic cell has also been attributed to synergistic couplings of primitive prokaryotic cells.

Ants maintain aphids in specially constructed nests, and feed upon a rich nutrient liquid secreted by the aphids. The aphids receive protection, harborage, and care from the ants. The ant/aphid "farming system" forms remarkably successful exploiters of plants.

Symbiotic relationships between species are biological examples of synergy. These symbiotic couplings enhance the abilities of the synergistic complex to capture and utilize energy. Intestinal protozoans in termites digest the cellulose in wood after termites have masticated it. In turn the termites are provided with digestible metabolic products by the protozoan fauna. Without the protozoans, termites could not digest cellulose. Without termites, the protozoans would not be afforded a masticated cellulose mixture. Together the termite/protozoan synergistic complex makes the most effective existing system for utilizing wood.

Any human being is a negentropic system. It requires energy to maintain and increase its structure and information content. If energy is not continually passed through your body, it will die and decay. A decaying body is an entropic system.

URBAN PLANNING SYSTEMS: A highway system can be thought of as a negentropic system because of the continual energy input necessary to maintain a good roadbed and safe driving conditions. The roadbed must be repaired, salt spread to minimize ice and snow dangers, white center lines painted, and guard rails constructed for safety, etc. All these maintenance functions require energy inputs (attempting to maintain order in the face of the continual trend toward disorder).

SYMBOLIC/PHILOSOPHICAL SYSTEMS: Languages are highly negentropic systems that purposively contain information. The energy required to develop and maintain the language negentropy is considerable. This energy is needed by any individual seeking to learn a new language or to write an essay in a familiar language. Occasionally linkages of words occur that are synergistic. These synergistic word linkages communicate some higher meaning or more vivid impression, as in the classic poem or elegant phrase.

SOCIAL SYSTEMS: Components of social systems or social systems themselves compete for control of energy. Since social systems are negentropic, they require this energy for maintainence. In fact, the more ordered (negentropic) a social system is the more energy is required for control. Totalitarian social systems require enormous police forces and control agencies that are non-productive yet require energy. Without energy, social systems will degenerate into anarchy.

8. SYSTEMIC EVOLUTION

Systemic evolution is the most fundamental of all systems "processes." It is also a "process" that literally generates new systems "structures." Therefore, this systems pattern is, in itself, a unification of "structurprocess."

Most systems have evolved strategies for the manipulation and control of their environment; they capture and use energy and material from other systems. The mechanism of energy transformation is called restructuring.

The system doing the restructuring literally transforms part of the environment into itself. Since this process contributes to the stability of the system, it is crucial to understanding how systems come into being and are maintained. Restructuring focuses on what happens to the input; it concentrates on the mechanics and efficiencies of the transformation process within the system.

Restructuring mechanisms fall into two major categories--"absolute" or "flexible." The type that leads to longest stability is the "flexible" mechanism. When the environment changes, the flexible restructuring mechanism can adapt.

This role of "flexible" versus "absolute" restructuring strategies occurs throughout the history of the evolution of species. It also occurs throughout the history of evolution of civilization and societal systems, especially political systems. The tendency of people to favor an absolute mechanism of restructuring in their social systems actually causes failure of designed systems because change is natural to all systems. The restructuring mechanism must allow for it.

The concept of restructuring is closely tied to the concept of systems-level reproduction and multiplication. Many replicates of a system are necessary for it to succeed as a system. Availability of many replicates allows each to serve as a subunit for the next level of complexification, therefore, giving the system even longer term stability.

One strategy accomplishes restructuring for replication using high reproduction rates, i.e., turning out a lot of offspring for survival--insects, fish. This mechanism exerts little control over the environment.

Another strategy accomplishes restructuring by low reproduction, but it devotes more energy after the fact (after birth) to controlling the environment. Both strategies have been successful, although the former has the longer history and is more consistent with natural systems design principles.

In the discussion of entropy in the previous section, it was described as a measure of the disorder and randomness in a system, usually a closed system. The Second law of Thermodynamics was cited as the reason the universe tends to increase in entropy: all entities progress to their lowest energy state.

However, to arrive at rest, to achieve its lowest energy state, uncomplemented (incomplete) modules are probabilistically pushed in the direction of fulfilling their potential complementarity. For example, positive and negative charges seek their counterparts in atoms. When not in balance, no matter how large the complex, whether it be on the level of ions or macromolecules, the residual charge will seek an opposite charge until it meets one.

This tendency for an entity to seek completion by complementarity in order to approach a state of rest is defined as its quest for neutrality. It is actually the demand for all systems to reach their lowest energy states. But in the term neutrality quest we focus on how entropy, in some cases, actually generates negentropic complexes, as in the above example of atomic balance.

So, entropy in the form of neutrality quest actually causes small pools of negentropy to form; these then become foundations for larger pools of negentropy, and so on. The magnitude of the negentropy is actually quite small, however, compared to the amount of entropy that is its environment and generator.

These patterns of energy flow and transformation are basic to the consideration of the mechanics of general systems evolution. To further describe the "process" that generates new systems "structures," two mechanisms of systems evolution, counterparity and concrescence ratio, are introduced in this section.

a. Counterparity

The concept of parity may be defined as equality, equivalence, or similarity, as in amounts, status, or character. When joined to the word "counter," it refers to two paired entities coexisting on the same hierarchical level, even in the same system, that are equal but opposite. An example of two such entities was cited earlier: the positive and negative charges on the atom. Another example on this level might be the requirement for electron pairs of opposite and complementary spins to complete orbitals in the shell of atoms. This phenomenon is a characteristic of a thermodynamically stable arrangement.

Counterparity is certainly the arrangement most often encountered in nature and hence may be considered the most selected for on a probabilistic basis.

There are two types of counterparity: satisfied and unsatisfied. Satisfied counterparity refers to opposite, but equal entities coupled together in a local space/time configuration. An example would be paired electrons in outer shells of elements. Their opposite nature (consisting of opposite spins) causes them to bind together as if each has what the other needs. Once coupled, however, they are "satisfied," i.e., they are not conducive to further combination. The energy used in the combining act appears to originate in part from the lack of wholeness of each complementary counterparitor when alone. When merged, the energy for combination is tied up in the act of structuring, and energy becomes a cluster of matter.

Unsatisfied counterparity refers to the unpaired members of a potential couplet of opposite, but equal entities that have residual energies for combination.

The fundamental dualities of matter and energy apparently create the concept of "attraction" from the lowest to the highest levels of the natural hierarchy. The attractions lead to an immense number of possible combinations. It is this fundamental attraction that provides the large populations of variants that comprise the raw material for systems-level evolution.

Overall, the concept of counterparity is crucial to explaining the hierarchical nature of systems. The classic representation is that of subsystems, complexing into systems, giving rise to super-systems. Satisfied counterparity is usually accomplished in the act of building a larger structure.

An entity with all counterparity completely satisfied would be very stable, but at the same time would be unable to complex and unable to serve with other such elements as the basis for systems evolution and interaction (e.g., neon). There is, then, a need for unsatisfied counterparity to balance this stability with its residual energies for combination--its potential for systems interactions.

b. Concrescence Ratio

The word concrescence comes from the Latin roots, con--"together" and cresco--"grow," and hence is defined as "to grow together" (to coalesce). As seen in the last section, counterparities cause coalescence. The concrescence ratio is the sum total of satisfied local counterparities divided by the total of unsatisfied local counterparities. It is an expression of the probability that an entity may successfully function as an element in a system of the next higher level of complexity.

Satisfied counterparity is an expression of the central stability of an entity. It provides the elements of that level with stability of transtemporal identity.

This is of obvious importance to the capability of that entity to act as an element or a subunit of a more complex higher level system. The more centrally stable the entity, the higher the probability of its serving as a subunit. If an entity is of only fleeting existence relative to its environment, it has a lower probability of serving as a subunit.

Unsatisfied counterparities are said to be in peripheral instability. This peripheral instability leads to the interaction of this entity with an entity of complementary disparity. Since the original peripheral instability of the two participating entities is now satisfied, the resulting complex is neutralized and becomes more stable than either of its subunits alone.

Concrescence ratio then, may also be defined as the relative magnitude of central stability (caused by unsatisfied counterparities) to peripheral instability (caused by unsatisfied counterparities).

These two factors of central stability and peripheral instability with their tendency toward satisfied complementarity may help people to predict the probability of concrescence of an element. The ratio of "stability-to-instability is a mathematical definition for the participation of the entity in further evolution.

EXAMPLES OF SYSTEMIC EVOLUTION

ECOLOGICAL SYSTEMS: Counterparity is a fundamental theme in biological and human/environment systems. Predator-prey and growth-decomposition are always intimately linked in biological communites. Whenever new organisms evolve, decomposers and predators are sure to appear to exploit them. Development of biological systems involves new producers, new predators or consumers, and a sequence of increasing complexity called succession by ecologists.

Human/environment is itself a counterparity. People pollute and release effluent and waste heat. The environment detoxifies the pollution and attempts to restore a balance. The environment responds to everything people do.

ECONOMICS SYSTEMS: Driven by energy and competition for profits, economic systems evolve. The economic configurations that usurp the greatest profits persist to the exclusion of the less successful competitors.

SYMBOLIC/PHILOSOPHICAL SYSTEMS: Languages certainly evolve: they are always changing as a reflection of the culture they represent. In fact, the study of languages is a tool in tracing human physical and cultural evolution.

SOCIAL SYSTEMS: The principles of counterparity and neutrality quest are apparent in the evolution of political systems. Counterparities that seek neutrality in political systems include peace and war, freedom and control, equality and possibility for advance, and so on. In a purely anarchistic state, people feel the need for some order and tend to form some political unit. In an overly authoritative or totalitarian political system people have a history of revolt, seeking more freedom.

E. EXAMPLE APPLICATION: AN APPROACH TO AN ENVIRONMENTAL PROBLEM USING SYSTEMS DIAGRAMMING AND SOME GENERAL SYSTEMS THEMES

In this section, the tools of systems diagramming and general systems themes will be applied in the depiction and analysis of an environmental problem area. Coal mining in Appalachia is a real life situation that can be used to help identify "systemness" in the human environment.

A brief synopsis of the coal mining controversy is presented here. It is followed by some systems insights into the coal production process.

1. Synopsis of Problem

Appalachia is geographically difficult to define. It includes areas of valleys, plateaus, and highlands of the southern Appalachian Mountains in parts of West Virginia, Ohio, Kentucky, Tennessee, North Carolina, and Georgia. Coal has played a dominant role in the economic and social well-being of major parts of Appalachia for most of the 20th century. Prior to World War II, underground coal mining was the rule. Surface mining began in Kentucky about 1825 and has increased steadily since World War II because it is safer, cheaper, and allows for better resource recovery than does underground mining. The fatality rate for underground mining is more than five times that of surface coal mining. Productivity in underground mines is about 15 tons per man day compared with about 35 tons per man day for surface mining. And the average recovery factor for underground coal mines is 57%, compared with 50-100% for surface mining.[23]

The dominant type of surface mining is called strip mining. It involves the complete removal of overburden such as soil, rock, vegetation, and other surface materials to reach the desired mineral deposit, coal, below. The overburden removed commonly is up to 100 feet thick, but may reach 300 feet under economically favorable conditions.

Both underground and surface mining involve adverse effects on humans and the environment, but the damage from surface mining is vastly greater. The adverse effects of underground mining are chiefly subsidence (soil shrinkage), acid mine drainage, abandoned mine fires and mine waste (gob) disposal. These problems, while serious, are localized (except for acid mine drainage).

Surface mining, however, causes problems over much greater areas and is, therefore, more devastating to both people and their environment. The prominent environmental and social problems caused by surface mining in Appalachia are listed below.

- Silting. In Kentucky, Cane Branch Creek lies within an area affected by stripping. This area has accumulated about 1,000 times the amount of silt (30,000 tons of silt per square mile) found in Helton Branch stream (27.9 tons per square mile) which drains an area that has not been stripped.[24]
- Slope instability. Landslides and mudflows are increased by adding unstable spoil piles to slopes. In mountainous regions, slides have been caused by stripping on an estimated 1,700 miles of slopes.

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[23] Reudisili and Firebaugh, "Perspective on Energy," p. 142.

[24] H.M. Caudill, My Land is Dying, (New York: E.P. Dutton, 1971).

- Poisons. These include sulphuric acid, ferrous sulphate, and ferric hydroxides, which commonly increase by a factor of 10 in strip mined areas as compared with virgin land.[25] The concentrated poisons pollute surface and subsurface water, severely reduce aquatic life, decrease oil activity, and retard growth of vegetation.

- Floods. Loss of surface vegetation from stripping and acid mine waters causes increased, though localized, rainwater runoff rates. The increased runoff causes small but devastating floods to small homeowners along the many streams and small tributary ravines.

- Population migration. The local population tends to migrate away from the coal producing areas. The 1970 census showed that 80,727 Kentuckians left the state since 1960. Many emigrated because of the adverse conditions associated with strip mining. Land was being stripped at a rate of up to 24 square miles per year. Many undoubtedly left because of advances in mechnized mining, which caused widespread unemployment in the coal fields.

The adverse impacts, both environmental and social, of coal mining in general--and strip mining in particular--are likely to be reduced or neutralized over the long term in Appalachia as indicated by the recent trends toward land reclamation and depletion of resources.

Strip mining for coal is environmentally the most adverse method of mining coal. Although stripping coal resources has increased in recent years, it still constitutes only about 7.5% of the total United States identified coal resources.[26] However, a changeover from surface to exclusively subsurface mining is in the distant future. The general prognosis for the Appalachian coal region includes an increase in surface coal from 70 million tons in 1973 to 165-359 million tons in 1990.

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[25] Caudill, Land.

[26] Donald H. Brobst and Walden P. Pratt, United States Mineral Resources, U. S. Geological Survey Prof. Paper 820 (Washington, D.C.: U.S. Government Printing Office, 1973).

2. Systems Insights

If damage to the environment and to people were to be foreseen and prevented, coal mining in Appalachia should have included consideration of a large number of systems.

The major goal was to provide coal in tonnages sufficient to supply power for private and public utilities, coke for steel making, energy sources for space heating, and raw materials for carbon based synthetics. To this end, the system of coal extraction was geared up to produce the maximum amount of coal for the minimum dollar cost. Immediate short-term maximum production at minimum dollar cost was the primary goal, to the exclusion of consideration for other interrelated systems such as the environment and people.

In short, the routine outlook or worldview of people in the United States during the coal mining years prior to the 1970s did not really incorporate short or long range environmental costs, although personal health and to some extent social costs were considered and acted upon. The purpose of the coal mining system was limited to the extraction of coal. All other considerations were thought to be external to the system and were negated.

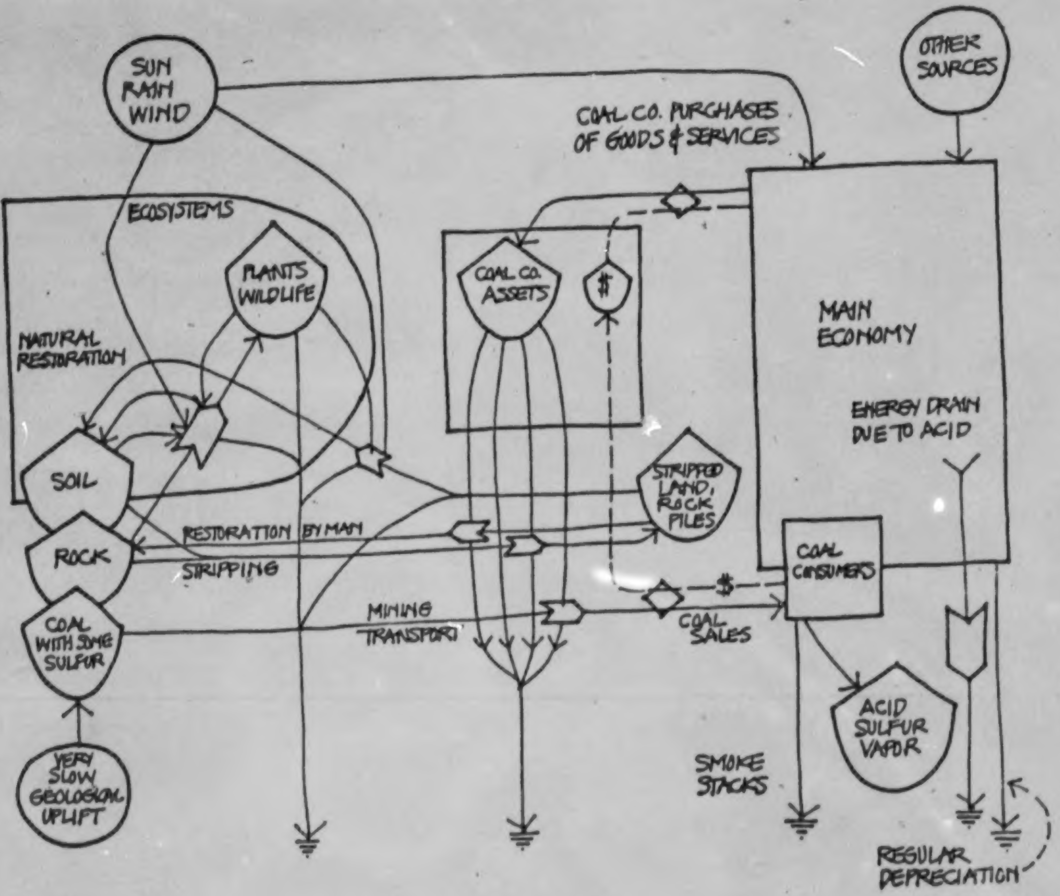
The boundary conditions of the coal extraction system were humanocentric, and as it turns out, unsympthetic with the region's natural environment--that is, the coal extraction system considered coal as the only input and as the total output of the system. The output coal was hauled from the extraction site, and other real outputs such as sulfur and its toxic compounds were not considered--either as output in this system or as input to the soil and water systems of the surrounding environment.

Thus the coal extraction system was a single purpose, insulated system, excluded by design from other actual operating systems. This helped ensure a lack of recognized feedback from interrelated (but excluded) environmental systems. Feedback to the coal system in the form of landslides and mudflows that indicated slope instability was fed into the coal extraction system but was not used for designing corrective measures. Feedback, in the form of deranged soil, lost timberland from stripping, and water pollution from over-concentrations of newly exposed metals and sulfur compounds was also linked to coal extraction but was not acted upon. The real concept of systemness was either misunderstood, or if understood, was neglected in the routine of planning for coal extraction. As a result, linkages among the real operating systems including, for example, the physical, biological, and human environment, could not operate. Therefore, the coal extraction system was not naturally regulated: its rate of output (thousands of tons of sediment and spoil per year) far exceeded the stable input load limit of the surrounding environmental system (tens of tons of sediment per year).

Thus, the environmental system became unstable. Since linkages between the coal extraction system and the environmental system were excluded, feedback as a regulatory mechanism could not operate, and the interrelated systems moved farther from equilibrium.

The result of this imbalance was failure of certain environmental systems: fish and vegetable life died in streams, soil became locally non-arable, and water became non-potable in places because the natural processes could not adequately dilute the toxic sulfur compounds from acid mine drainage. Other indicators of environmental instability were landslides, mudflows and flooding.

Also, ultimately, the failure of the environmental systems served as a type of feedback necessary for the survival of the coal extraction system. As human and social systems also began to fail, citizen groups were formed, town meetings held, and recommendations given to those people in a position to change the coal extraction system.


SUN RAIN WIND
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COAL CO. PURCHASES OF GOODS & SERVICES
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COAL SALES
COAL WITH SOME SULFUR
ACID SULFUR VAPOR
SMOKE STACKS
VERY SLOW GEOLOGICAL UPLIFT
REGULAR DEPRECIATION

SYSTEMS DIAGRAM: THE COAL EXTRACTION SYSTEM

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PROBLEM-SOLVING
AND
DECISION-MAKING

A. INTRODUCTION

The problem-solving quest is established by the interaction of two sets of variables: (1) the constraints imposed by the nature of the solution sought; and (2) the nature and/or posture of the problem-solver. The combination of these two aspects determines a routine for questing. Four major routines for problem-solving are:

1. artistic--search for form;
2. craft--search for style tradition;
3. technological--search for methods and valid routines;
4. paradigmatic--search for verities and constancy.

These routines all have three limitations in common: media, tools, and protocols. They may be utilized singularly or in combinations, depending upon the nature of the problem and the creativity of the problem-solver.

A complex decision-making model must:

- be based on systemic, holistic methods for dealing with complex environmental issues;
- utilize data organizational tools which enhance human perception;
- provide the basis for the disciplined development of new knowledge and new, more comprehensive and integrative strategies;
- have the ability to adapt and change itself;
- enable the user to explore and mediate conflicting dimensions of public/private, individual/social, natural/man-made systems;
- recognize the utility of intuitive methods in addition to rational, scientific means;
- generate a variety of implementation strategies;
- generate appropriate decision criteria for evaluating alternative solutions;
- enable the user to explicate value components of the decision process.

B. THE RATIONAL DECISION-MAKING MODEL: AN HISTORICAL ANALYSIS

During the 1950s, a number of major works examined the nature of public decision-making. (Dahl and Lindblom, 1953; Meyerson and Banfield, 1955).[1] A major theme of the debate, one around which most of the other issues can be organized, is the relationship between logical methods for arriving at optimal decisions for the public welfare, and the various other influences that shape public decision-making--e.g., the political process, economic self-interest, and personal values.

For a period of a few years in the late fifties and early sixties, political theorists and planners debated ideal decision-making models, frequently complete with flow charts and neatly ordered procedural steps. These models remained at a high level of abstraction and generally expressed a similar structure. Among the most well-known of these expositions is a classic article by Edward Banfield, which presents the following model for public decision-making: (1) elucidation of goals; (2) discovery of alternatives for action; (3) projection of consequences for available alternatives; (4) choice of the optimal alternative; (5) programming; and (6) evaluation of the consequences of action undertaken, thus providing for feedback of information to the next cycle.[2]

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[1] See Bibliography for full references cited in this essay.

[2] Edward Banfield, "Ends and Means in Planning," International Social Science Journal, XI:3 (1959), pp. 361-368.

These models were no sooner clearly defined than they became the subject of a hot debate led by writers such as Etzioni (1968), Altshuler (1965), and Kuhn (1970).

Altshuler examined decision-making on a case-study basis in several different political contexts. He determined that a need to be re-elected and other similar factors were more important than any rational process in determining policy and in deciding what is best for the public interest.

The rational model was also challenged by the work of Thomas Kuhn, who studied the directions taken by research in the sciences. The analog to the Banfield model in the sciences would be an agreed-upon plan for research, stressing those areas most related to the public interest. However, Kuhn suggested that the direction for scientific research is determined not by the presence or absence of new major discoveries, but by the acceptance of paradigms that transform the field (often over the violent resistance of those committed to theories that are being supplanted). Research efforts follow these paradigms rather than any predetermined plan for the public interest.

The third major critic of the rational model, Amitai Etzioni, drew on the work of two earlier writers, Albert Hirschman and Charles Lindblom. Hirschman and Lindblom (1962) synthesized some of the major criticisms of the rational decision-making model and created a new model which they called disjointed incrementalism.

As described by Hirschman, Lindblom, and later Etzioni, disjointed incrementalism is similar to a competitive economic model in that each decision-maker is expected to represent only the interests of his or her own constituency. The public welfare is presumed to be secured by the interaction of these conflicting needs and desires.[3] Consideration of alternatives is limited, however, to those choices that differ only incrementally from existing policies. Thus, incrementalism has an inseparable conservatism, which makes it unlikely that major changes will occur in government actions. Etzioni notes that this prevents public decisions from having a transforming effect on the government or on the services it provides.

During the years that rational decision-making as a model for reality was being attacked by the writers discussed above, other authors were adding increased sophistication to the concept of rationality in decision-making. Jurgan Habermas (1973), Melvin Webber and Horst Littel (1972), and Robert Dahl (1970) all presented perspectives on an interesting theoretical debate about levels of rationality in decision-making.

Of more immediate importance for this report were developments in systems theory which were intended to provide the decision-maker with the correct context (the system) and with a broader base of information and tools for choice than had previously been attempted. In this way, systems analysis provided a new foundation for rational decision-making.

Systems analysis is discussed elsewhere in this Sourcebook. Aaron Wildavsky (1966) and C. West Churchman (1968) provide classics in the field that might be used in a discussion of decision-making.

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[3] There is an extensive literature on the fallacies inherent in this assumption. See Mancur Olsen (1965); James Coleman (1964); or Kenneth Arrow (1951).

C. THE PROBLEM-SOLVING/DECISION-MAKING PROCESS IN THE CONTEXT OF ENVIRONMENTAL EDUCATION

As shown above, the rational decision-making model has been criticized and has, as a result, been improved. In a later section of this paper (Section E), a decision-making model reflecting some of the criticisms will be presented. For example, in the management model for decision-making (see p.), there is a step labelled "problem and opportunity detection." In this step, "opportunities" could include political circumstances such as election of a mayor interested in environmental education. The rational model is thus revised to reflect the political and other limitations that were discussed earlier.

An equally important consideration reflected in the following discussions is a concern for and interest in the environment. This concern does not appear explicitly in the early discussions of rational decision-making, but it should be an important part of any decision-making process that occurs now.

Examining the rational model in the light of the criticisms that have been discussed, we can recommend a set of issues that might be useful to consider in decision-making. This list of issues is suggested by considering the criticisms discussed, but it is not exhaustive.

1. Equity and Valuation of Future Benefits

In considering needs, goals, and objectives, the concepts of equity and valuation of future benefits may be introduced. The equity of providing differing benefits for different groups may be discussed. The question of effectiveness of centralized decision-making that does not include input from all affected groups might be explored. Explicit consideration of future benefits and costs might also be included.

Equity considerations deal with the share of resources made available to sectors of the population. Decisions frequently alter this balance to favor some groups over others. "Equity" generally refers to an effort to make the share of resources more equal between groups or individuals.

In systems analysis the consideration of valuation for future benefits is called the "social discount rate" and is estimated numerically when possible. It is the relative value of one unit of benefit at a fixed time in the future compared with the value of the same benefit if it were available in the present. An assumption is made that a price is required to compensate for deferred gratification. When discussing money, that price corresponds roughly to the current interest rate. When discussing resources, the finite nature of the resource must be considered in evaluating the present against future benefits before deciding between alternative courses of action. For a discussion of the theory of social discount rate, see Mishan (1972). For a discussion of the importance of future thinking in resource use, see Kent (1970), or Foin (1976).

2. Data/Information Acquisition and Use

In the information-gathering phase of decision-making, the types of data to be gathered should reflect environmental awareness. Information from the natural as well as the social sciences might therefore be used.

Increased environmental awareness has created a need for new forms of interdisciplinary communication. Though some forms of data from the natural sciences, for example, have been collected over a long period of years, the information is frequently in a form that makes utilization difficult for decision-makers (particularly those who are not trained in the sciences). Development of new tools for information gathering and use by decision-makers is an important new field. For representative literature, see McHarg (1969) or Stewart (1969).

McHarg's system of overlays representing different significant natural factors (soil type, access to water, vegetation, and other factors) has had a widespread influence on the study of the environment. At a simpler level, students of decision-making who are concerned with environmental impact should be familiar with the major sources of available data: soils maps, USGS topographic maps, aerial photos (if available), street maps, census data, etc. The fragmented nature of this information will be obvious and should lead to fruitful discussions on the current process of restructuring the information we have about the environment.

3. Available Tools for Implementation

Development of alternatives in the decision-making process can be guided by an awareness of the technological, legal, and administrative implementation tools available. This is in contrast to the early rational model, which sometimes called for devising alternatives on the basis of theoretical rather than practical possibilities. Current decision models may include the consideration of new discoveries in the area of implementation.

Development of alternatives for consideration by decision-makers depends partly on the technology that is available, for example, to cool a factory without water pollution. Implementation of alternatives also depends on the availability of legal and administrative techniques. For example, widespread acceptance of planned unit development (PUD) zoning in the past few years has made possible new alternatives for urban and rural development. Most decisions depend on the tools and technology available. Literature for this area is specialized and must be sought for individual cases as they are defined. Some examples are McCaull and Crossland (1974) for technology, and Heyman (1973) for legal and administrative techniques. General implementation literature includes Pressman and Wildavsky (1973) and Jantsch (1972).

4. Environmental Impact

In considering the choice of alternatives, analysis of the environmental impact of each alternative should be incorporated (a factor often not considered in early decision-making discussions). Political representation and the realities of distribution of political power also affect the choice of alternatives, as revealed by case studies such as Altshuler's.

The environmental effects of public decisions are rarely discussed completely. Frequently, they are not explicitly discussed at all. It may be helpful to translate statements made about a proposed decision into environmental terms. For example, the statement "The new factory will be water-cooled" translates into environmentally significant statements about factory location (near a river) and impact (water temperature will be raised). General references on the environmental impacts of major public and private decisions include Perloff (1969), and Miller (1975).

Most decision-makers are aware of political factors, but the extent to which political considerations are made explicit in the decision-making process varies. In studying decision-making, questions should be raised about how the relevant political entities function, i.e. Are key people elected or appointed? What is their base of support? Consideration should also be given to the benefits and losses to affected groups that would result from the alternatives under consideration. Frances Piven and Richard Cloward (1971) point out that an unheralded result of the Model Cities Program was an increase in urban Democratic voter registration, which was extremely significant for city politics. This consequence, however, did not form an explicit part of early discussions about the program. The Piven and Cloward case study illustrates the complexity and importance of political factors in decision-making.

D. ISSUES IN DECISION-MAKING AND THE ENVIRONMENTAL ENTITIES

The Environmental Education Act of 1970 specified that consideration of the following entities must be part of the environmental education process: population, pollution, resource allocation and depletion, conservation, transportation, technology, urban and rural planning, and energy.[4]

This section will discuss decision-making with respect to two of these environmental entities: population dynamics and urban and rural planning.

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[4] "Energy" was included in a 1978 amendment to this Section by the Congress.

Example: Population Dynamics

The range of decisions directly affecting population dynamics is very great. Examples include the target population to be sought for a local community and the balance (age, socioeconomic, etc.) that is considered desirable.

There are at least three ways to study such decisions: to simulate them through role-playing or imaginative essays; to participate in them (as informed community members); or to analyze them as non-participant observers. For each of these methods, a consideration of the steps included in the rational model can be useful. Criticisms of the rational model have been presented in the preceding section; rational decision-making models should be used with these criticisms in mind.

A modified rational decision-making model might be used to analyze decisions in the area of population dynamics as follows:

1. Goal Setting/Needs Assessment

Equity. Growth control may drive housing prices up and keep out jobs, thereby making it difficult or impossible for low or moderate-income peoole to remain in the area or to move there. One of the goals adopted by decision-makers might be to retain a socioeconomic balance in the residential population in the area. If access for less wealthy groups is going to become more difficult due to the adoption of growth control measures, this consequence can be explicitly discussed.

Valuation of future benefits. Population dynamics is a future-oriented subject; present concern with population growth stems from projections of the future that show that present trends will produce unwanted results if continued. Population or growth control measures are usually difficult to implement; success depends on how strongly a concern for the future is felt.

2. Data/Information Gathering

Data from the natural sciences. Data gathering efforts should include measures of the impact of the existing and projected population configurations on the environment. Critical factors include housing densities, number of cars per family and other measures of energy consumption, and environmental vulnerability of the land that might be used for future development (carrying capacity).

Data from the social sciences. The problem of population growth is sometimes discussed uncritically. Information about economic pressures, the history of migration patterns, social changes in the population (in the relationship between the races, for example), and changes in the birth rate and age structure of the population can be used to clarify the issues in population dynamics that are important to a community engaged in a problem-solving decision-making process.

3. Development of Alternatives

Implementation tools available. Interpretation of the constitutional right to travel is currently being decided by the courts. The role of the court in recent growth control cases may be inappropriate: questions such as "fair share" low-income housing allocations require regional planning and negotiation, which is not easily conducted in the context of a lawsuit over a specific ordinance. In addition, questions of legal procedure often determine the outcome of a lawsuit but may be irrelevant to the population issues at hand.

In the area of technological development, new methods of birth control are being developed, raising complex questions about the morality of intervention in this area. Recent legal, technological, and ethical developments in areas such as this can determine the range of alternatives available to the decision-maker in the area of population dynamics.

4. Choice of Alternatives

Environmental impact. Conclusions about environmental impact can sometimes be conflicting. For example, growth control often implies lower-density development. Low-density development has environmental advantages because a smaller proportion of the land is disturbed by development. However, more road mileage per dwelling is required, and low density development usually precludes effective mass transit systems. Thus, the advantages and disadvantages in terms of environmental impact must be weighed in the decision-making process.

Political representation. Those most affected by decisions in the area of population dynamics are often not present to speak for themselves. This is particularly likely to be true if decisions are exclusionary (i.e., if they have the effect of excluding people with lower socioeconomic status than present residents of the area). There may be no groups within the existing community who wish to represent the interests of potential migrants to the area. Future generations may be another unrepresented group. The question of unrepresented or under-represented groups might be raised in decision-making about population dynamics.

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Example: Urban and Rural Planning

Decisions within the environmental entity "urban and rural planning" include land use, zoning, and design considerations (urban design, scenic highways, etc.). The modified rational decision-making model can be applied to urban and rural planning in the same way that it was applied to population dynamics:

1. Goal Setting/Needs Assessment

Equity. Land use planning has sometimes had the effect of restricting access for the poor and for minority groups. Provision for low - and moderate-income housing, for rentals, and for jobs for these groups of residents can be important considerations in many planning decisions.

Valuation of future benefits. Planning for future benefits is particularly difficult when present economic gains must be foregone. This is frequently the case in decisions affecting the environment. The decision to reserve a greenbelt around the city, for example, requires that the city or some groups or individuals within it must forego the profits that would result from development.

2. Data/Information Gathering

Data from the natural sciences. Soil and geology maps, slope, vegetation, areas of special natural or cultural significance, bodies of water or water-related lands (such as aquifers), and maps depicting present resource use (mining, timber-cutting, fishing, etc.) may form part of the basis for urban and rural planning decisions.

Data from the social sciences. Rural planning, where it occurs, frequently is based partly on natural environmental conditions, such as agricultural potential. Urban planning commonly relies on economic, legal, political, and sociological information in addition to purely physical considerations such as topography. Traditional methods of data use for planning--e.g., population, employment, and transportation forecasting; sociological surveys; or political case histories--can all be useful for decision-making in urban and rural planning.

3. Development of Alternatives

Implementation tools available. Traditionally, zoning decisions have dealt with density and type of development, street construction, and provision of utilities. Environmental awareness has led to the development of more flexible tools such as Planned Unit Development zoning, which allows the developer to arrange development density on the site according to the characteristics of the site. Other examples include slope formulas, tree cutting and sign ordinances, and shoreline development permit regulation.

4. Choice of Alternatives

Environmental impact. Formal environmental impact reports (EIR's) are frequently required for major development decisions, but smaller decisions should also include specific recommendations about environmental impact. Under present regulations, developers sometimes divide a larger project into smaller parcels to avoid the requirement to prepare an EIR. The cumulative impact of small projects may be more serious than that of a single large project.

Political representation. A recent concept in urban planning is "advocacy planning": planners and other professionals choose underrepresented groups to serve. The professional acts as a consultant, often unpaid, to the group to assist it in promoting its interests in the decision-making process. Advocacy planning is one method of helping to ensure that all affected groups are heard in decision-making.

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E. A MODIFIED RATIONAL PROBLEM-SOLVING/DECISION-MAKING MODEL

In the context of the EETTM, problem-solving and decision-making skills are needed by at least three target populations: (a) the high school students who are enrolled in energy/environmental courses; (b) community/adult leaders; and (c) the high school teachers and trainers of these two target populations. Individuals in each of these populations need to understand the processes involved in solving environmental problems and making decisions, and to apply the appropriate skills to make environmentally aware decisions about individual and societal concerns.

High school students, for example, need certain kinds of tools and strategies to help them make environmentally aware decisions about individual alternative career and lifestyle choices. Adult community leaders, on the other hand, are confronted with additional environmental problems and issues at the societal level which in turn require different levels of understanding and different application strategies. There is consequently the need to identify a generic decision-making/problem-solving model from which appropriate and effective strategies and tools can be derived to match the differing needs and purposes of the target populations served by the Environmental Education Teacher Training Models.

No single definitive model currently available will satisfy the purposes of all the target groups specified in the EETTM(s). It is necessary, therefore, to incorporate elements/components from the available models and generate a new model--a dynamic, complex decision-making model specific to the needs of the designated target groups. The criteria for constructing such a model are presented on the following page.

1. *The Model must be based on systemic, holistic methods for understanding and dealing with complex environmental issues.*

The complexity of environmental problems and issues requires that the decision-making/problem-solving strategies be general-systems-theory oriented and transdisciplinary, since the combined knowledge of one or even more than one field of study cannot adequately comprehend the parameters of the EE problem configuration or the possible alternative solutions. These transdisciplinary methods must be conceptually integrated so they can be used throughout the decision-making process in an integrative manner instead of being used separately or sequentially.

The need and importance of using systemic, holistic, transdisciplinary methodologies is specified in the EE Act. Researchers in the field have recognized the need to develop methodologies that deal creatively and effectively with the complexity involved in social environmental issues. Emery and Trist (1973), for example, have specified the need for a unit of analysis larger than and inclusive of the systems involved. Following the same reasoning, Warfield (1976) notes that societal problems are highly complex, involve multiple interactions amoung various elements, and are highly interdisciplinary or transdisciplinary with social, economical, political, environmental, and emotional factors intertwined. Coping with such complexity dictates the necessity to rely on a host of disciplines.

2. *The Model must utilize means that enhance human perception and enhance the aggregation of human perceptions to capture their synergistic qualities.*

Warfield (1976) discusses criteria for the design of systematic methods for treating complex problems. He indicates that although the ultimate test for the methodology is whether it is beneficial in ameliorating societal problems, it is also important during the process to enhance human perceptions and create the means to enable the aggregation of these perceptions to be channeled into the development of more insightful models of systems. He concludes, in fact, that a methodology for grappling with complexity has to be a methodology for human learning.

3. *The Model must go beyond the prescriptive function and provide the basis for the systematic development of new knowledge and new, more comprehensive and integrative strategies.*

The model must have inherent within it, the ability to perpetuate and change itself. The need for a decision-making theory to go beyond the prescriptive function is discussed by Mitroff and Betz (1972). They maintain that a theory should provide the basis for systematically investigating the development of a meta-theory to deal with the conceptual areas that cannot be addressed within the prescribed framework.

4. *The Model must provide means that enable the user(s) to explore and mediate conflicting dimensions of private/public, individual/social, natural man-made systems.*

Providing mediative strategies is recognized as the most fruitful way of transcending the paradoxical nature of some problem configurations.

5. *The Model must go beyond rational, scientific means and recognize the utility of intuitive methods.*

Easton (1973) notes that there is room for the use of intuition or judgment in part of the decision process, and a need for hard data in other parts. Prescribing when and where intuition or data is most appropriate is something he categorizes as one of the essential creative elements of decision-making.

6. *The Model must be capable of generating a variety of decision-making methodologies and implementation strategies.*

The need for the generic model to generate a variety of decision-making methodologies and strategies is based on the perceived needs of the different potential user groups specified by the EETTM.

7. *The Model must enable the users to explicate value components of the decision process.*

A component of the decision-making model that enables users to address value issues and conflicting purposes is vital for dealing with social environmental problems. Churchman and Ackoff have elaborated a method that has the potential for ordering the relation between values and ascertaining which values people are most prepared to sacrifice, and whether support for a set of values is, over the long run, declining, stable, or increasing. A relevant discussion of value system design in Warfield (1976) describes such a component as a "...set of interrelated elements including objectives, constraints, evaluation factors, and criteria which provide a basis for rational decision-making." (pp. 182-3)

8. *The Model must generate appropriate decision criteria for evaluating alternative solutions.*

Applying inappropriate criteria, such as quantifiable means for dealing with qualitative concerns, is tantamount to answering the wrong question. Easton (1973) acknowledges the disenchantment with the single-objective decision process, which utilizes only return on investment or profit maximization criteria. A discussion of the need for utilizing different measurement methods for different types of objectives is presented in a discussion on systems engineering logic in Warfield (1976). It is suggested here that quantitiative elements may be measured either by deterministic or probabilistic methods, while qualitative issues indicate value judgments.

Generating appropriate decision criteria also requires the identification of social and environmental indexes, which enable the user to compare the various benefits to be realized from each proposed alternative solution. Warfield (1976) has indicated the importance of defining better social, urban, and environmental issues, and Mann has cited the work of Bertram M. Gross and Stanford Research Institute in the area of social indicators as initial attempts to clarify this problem.

An initial image of a generic complex decision-making model that incorporates these specifications is illustrated in Figure 1. This initial design attempt is based on Mann's (1975) adaptation of a paradigm of decision-making originally developed by Irwin D. J. Bross.

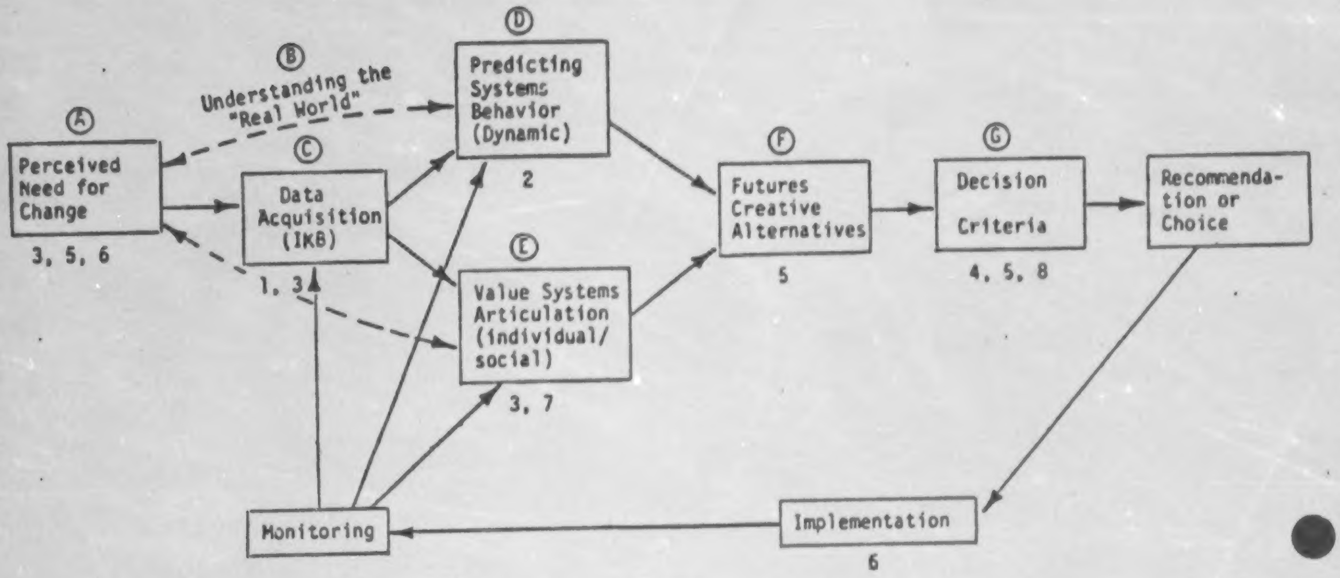
Ⓐ
Perceived Need for Change
3, 5, 6
Ⓑ
Understanding the "Real World"
Ⓒ
Data Acquisition (IKB)
1, 3
Ⓓ
Predicting Systems Behavior (Dynamic)
2
Ⓔ
Value Systems Articulation (individual/ social)
3, 7
Ⓕ
Futures Creative Alternatives
5
Ⓖ
Decision Criteria
4, 5, 8
Recommendation or Choice
Implementation
6
Monitoring

Figure 1. A GENERIC COMPLEX DECISION-MAKING MODEL

In Figure 1, the numbers adjacent to the components and processes refer to the model specifications outlined on the previous pages. The letters refer to the sources and rationale for the additions and changes to Mann's diagram, which are as follows:

A. According to Easton, the decision process begins with a perceived need for change. In the environmental problem configuration, this perceived need for change arises from an awareness of nested systems in conflict. This initial phase of the process includes a description of the decision-making environment and a characterization of the decision-making context.

B. The broken lines connecting the "perceived need for change" component and the "predicting systems behavior" and "value systems articulation" components emphasize the non-linearity of the development of a systemic understanding of the structure/process of the real world. This dialectical process of imagining, testing and receiving feedback is fundamental to an integrative understanding of the real world. This is shown here as a simultaneous interaction in two of the major domains/components of the decision-making process.

C. The procedures followed for acquiring and organizing data into meaningful information all have inherent limitations. These limitations are functions of the procedures, not the data. According to Warfield, for example, the basic flaws in acquiring and applying knowledge are in the ways of explorations; the traditional methods of inquiry are, in fact, incomplete. He notes that the social and behavioral sciences generally lack established mechanisms and linkages for collective exploration into complex issues, and furthermore, their current efforts are detrimental to the development of more integrative conceptual methodologies. Warfield presents a schema for "idea management" which addresses the nature of knowledge, how types of knowledge interact at the various levels, and what forms knowledge takes (i.e., descriptions, frameworks, algorithms).

   The Integrated Knowledge Base (IKB) for Energy/Environmental Education provides information organized to facilitate the achievement of integrated, anticipatory, design/planning decisions that cohere with the broad and diverse goals of environmental education.

D. Predicting systems behavior first requires an understanding of the range/parameters of "normal" performance of a system and an intuitive, hierarchical awareness of the components critical in maintaining the balance of the system. This understanding of system logic and function is crucial to diagnosing signs of system malfunction and obsolescence. Easton, for example, ascribes system malfunction to sudden or gradual internal changes and system obsolescence to changes in the external environment which make the system incapable of satisfying the new functions. Analyzing a system's performance in these terms requires the development of dynamic strategies capable of delineating complex, functioning systems in holistic terms.

E. Value Systems Articulation must occur simultaneously at the individual and societal level. This requires self/other referencing strategies that monitor and articulate the hierarchical nature of the value system of the individual "self" who initiated the decision process and also the value system of the "other" entities involved in and affected by the decision-making process. This self/other articulation represents an important dimension in characterizing the figure/ground decision-making context.

The EETTM provides some self/other referencing tools and others could be developed based on Easton's conceptualization of identifying and classifying the interests, assumptions and values of the influencer (the decision-maker) and the influenced. He presents, for example, seven assumptions about the nature of the decision environment and then displays the different solutions generated. Easton also schematically presents a decision-maker's different levels of influence and the potential conflict associated with these levels.

F. Generating futures creative alternatives can be systematically accomplished, according to Mann, through two types of prediction: consequential prediction asks, "If things continue as they are now, what will be the consequences?" Optimal prediction asks, "What kinds of futures are most desirable and what would need to be done to attain them?" The former proceeds by extrapolation and the latter by invention. Mann provides characteristic activities of these types of analysis. Easton also addresses the importance of generating scenarios about the future and offers guidelines for developing and evaluating workable alternatives.

An algorithm for generating alternatives, entitled "the anasynthesis strategy," is one of the tools already developed and available to users of the EETTM. This multiple entry/iterative strategy can be used for generating alternative solutions to environmental problems within a holistic, systems-oriented context. It represents an anticipatory design process which includes optimal evaluation of contingencies and is capable of generating and comparing multiple solutions. The emphasis during the process is on maintaining procedural holistic integrity as opposed to component optimization, which usually sacrifices holistic integrity.

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G. The primary emphasis of the EETTM is on a decision-making/problem-solving approach to the problem configuration characterized by nested systems in conflict, and it concentrates on the conceptual formulation of successful and probable creative alternative solutions. The evaluation and assessment steps of the decision-making/problem-solving process have not been addressed as fully, but are of equal importance.

The social planning process discussed by Warfield includes societal indices and qualitative factors inherent in the democratic decision-making process. These factors play an important role in the "Decision Criteria" step and in the "Monitoring" function, which provides feedback to many of the steps.

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ENERGY/
ENVIRONMENTAL
CAREER
RELATED
DECISIONS

A. INTRODUCTION

The horizon of energy/environmental careers is vast and expanding. Individuals interested in pursuing a career in this field are likely to encounter a great deal of information, most of which is difficult to integrate into a comprehensive knowledge base from which to make decisions. The problems associated with synthesizing and integrating the plethora of energy/environmental career-related information stem from confusion about the energy/environmental "field" itself and from a lack of attention to the aspects and corresponding issues influencing the field's future evolution. The purpose of this section is to: (1) delineate the various ways in which the field of energy/environmental careers is defined; (2) explore the aspects and corresponding issues that currently influence and will contribute to its future evolution; and (3) propose the design of an integrative structure to assist individuals in synthesizing information and creating bases for making decisions.

B. DEFINITIONAL PERSPECTIVES OF THE FIELD

In speaking of the energy/environmental "field" one immediately becomes aware of its complex and highly interdisciplinary nature. Fields are usually defined in terms of problems, and when one considers the multiplicity of disciplines and job-oriented activities related to solving energy/environmental problems that touch upon all of human/natural systems interactions, the definitional task becomes somewhat impossible. As one attempt has concluded, "...a precise definition of the 'environmental field' must be somewhat nebulous..."[1] It must be noted, in fact, that when one speaks of the energy/environmental field, only the environmental component is recognized. This may be due to the fact that when the field emerged in the early 1970s, it consisted primarily of jobs related to the monitoring and maintenance of clean air and water and solid waste management.[2] By and large, the environmental field has been and continues to be defined in terms of the implementation of governmental mandates to protect the quality of our environment. Changing foci of concern have resulted in the inclusion of other categories and professions. The greatest confusion as well as potential for expansion developed as a result of the energy "crisis" and ensuing job-related issues. This continuing energy focus and anticipative concern is accordingly reflected in the usage of the term "energy/environmental field."

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[1] Julian Josephson, "Where will all the Jobs Be?", Environmental Science and Technology, 9:9, (September 1975), p. 806.

[2] For characterizations see, for example, Special Report, Environmental Science and Technology, (August 1972); Council on Environmental Quality Reports; or EPA Reports.

1. Characterizing the Energy/Environmental Field

There are many ways in which information on the energy/environmental field is divided and presented. Figure 1 illustrates the structure generated from the government's ENVIRONMENTAL PROTECTION PROGRAM, which includes the major categories of Air Quality, Water Quality, Individual Hygiene, Radiation Protection, Solid Wastes, and Other.[3] Some studies incorporate the latter four into Health and Sanitation.[4] Under these categories, occupational opportunities are usually described in terms of the existent professions; e.g., engineers, scientists, and technicians are characterized in professional and/or technical terms. Incorporating these aspects into a graphic image illustrates the current most commonly shared perception of the energy/environmental field.

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[3] U.S. Environmental Protection Agency, Career Choices: Working Toward a Better Environment (1975).

[4] Ralph C. Graber; Frederick K. Erickson; and William B. Parsons, "Manpower for Environmental Protection," Environmental Science and Technology, 5:4 (April 1971).

Figure 1. AN IMAGE OF THE ENERGY/ENVIRONMENTAL FIELD

OCCUPATIONS	ENVIRONMENTAL PROTECTION PROGRAM EMPHASES					
	Air	Individual Hygiene	Radiation Protection	Solid Waste	Water	Other
Engineer						
Scientist						
Technologist						
Technician						
Aide						

Other attempts to characterize the environmental field reflect less structure and more arbitrariness. According to one perspective, for example, the environmental field is comprised of the following seven environmental careers:[5]

- environmental life scientists
- environmental physical scientists
- environmental engineers
- natural resource managers
- environmental monitors
- environmental technicians
- environmental laborers

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[5] James Hahn and Lynn Hahn, Environmental Careers (New York: Franklin Watts), 1976.

To illustrate the range of definitional possibilities, another perspective utilizes the theme, "Jobs that Save Our Environment," and classifies traditional occupations under fourteen environmentally related services, professions and disciplines such as: environmental health, law and writing, air and water pollution, and earth science, ecology, and oceanography.[6]

2. An Emerging Definition

Although the focus of attention in the field during the past few years has shifted to economic and employment implications of various energy policies, there have been no attempts to incorporate existent and/or emerging energy-related occupations into available characterizations such as the ones described on the previous page. This seems to reflect the absence of an awareness or consciousness of the whole field itself, rather than an oversight or conflict. Whether this stems from definitional or identity problems or is indicative of a particular stage in the emergence of a field is difficult to ascertain. What is emerging, though, in relation to energy concerns, is a definition of the field tied primarily to energy sources and technologies used to produce energy. In a 1974 study prepared by the National Planning Association on future demands for scientific and technical manpower, for example, projections were given for the following energy-related industries:[7]

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[6] Melvin Berger, Jobs That Save Our Environment (New York: Lothrop, Lee & Shepard Company, 1973.

- electric power generation, transmission, and distribution
- petroleum and natural gas extraction and refining
- natural gas production, transmission, and distribution
- coal mining
- nuclear power cycle
- equipment production for electric companies
- construction

It is interesting to note that within this focus on energy-related industries and sources, increasing attention is being given to "alternative" sources and technologies. For example, Megatech, a self-proclaimed pioneer in energy education, describes careers associated with the following sources:[8]

- solar electric
- solar thermal
- wind
- nuclear
- geothermal
- hydropower

The increasing job-related attention being given to alternative energy sources reflects a growing concern for demonstrating the economic feasibility of utilizing renewable energy sources.[9] This perspective is reflected in JOBS FROM THE SUN, a California Public Policy Center Study on employment development in the California solar energy industry.[10] Within this particular study, job creation potential was defined in terms of the following five categories:

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[7] Ivars Gutmanis; Rita A. McBrayer; Richard P. McKenna; and Richard Kotz, Demand for Scientific and Technical Manpower in Energy-Related Industries: United States 1970-1985, prepared for National Science Foundation by National Planning Association, Washington, D.C., 1974.

[8] Megatech Corporation, Energy Sources and Careers, (Billerica, MA: Megatech), 1978.

- collector manufacturing
- component manufacturing
- installation
- distribution
- indirect/induced

These categories are then described in terms of: (1) where the activities associated with each would take place (i.e., factory, on-site); (2) the nature of the work (assembly, administrative, design/planning); and (3) the level of competence required for the work (low level, highly technical, etc.).

The kind of information that is emerging in relation to career opportunities in energy-related fields is, as one can see, very diverse and varied in terms of levels of specificity. This holds true for the entire energy/environmental field, which remains amorphous. In addition to being defined by current and projected job opportunities, the boundaries of a field can be assessed through an examination of "influencing" or relational factors and corresponding issues. One must be aware, of course, that a conception of the influencing factors presupposes some notion of the constituent elements of the field, and any omission will tend to foreclose options that are not anticipated.

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[9] For one of the earliest reports in the nation on the employment potential of the following sources, see Daniel Haley, "Jobs and Energy," Operation Bootstrap, Renewable and Efficient Energy for New York State, The Legislature, Albany, N.Y. (March 1977), pp. 72-103.

[10] California Public Policy Center Study, JOBS FROM THE SUN, Employment Development in the California Solar Energy Industry, Los Angeles, CA, (February, 1976), pp. 32-50.

C. ENERGY/ENVIRONMENTAL CAREER-RELATED ISSUES

The energy/environmental field is shaped primarily by the larger cultural context in which it functions. To gain an understanding of future employment trends, it is important to examine anticipated cultural changes and related issues surrounding and subsequently defining the evolution of the field.

1. Cultural Changes

Scholars exploring the fundamental structure and evolution of Western society have identified a series of dilemmas that our country and other industrial nations now face. These dilemmas may be resolvable only through sweeping societal transformation. During an analysis of social problems carried out at Stanford Research Institute under the direction of Willis Harman, for example, the following four dilemmas inherent in our industrial society were identified as the core components of what has been termed the world macrocrisis.[11]

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[11] Willis W. Harman, "The Coming Transformation," The Futurist (February 1977), pp. 5-7.

THE GROWTH DILEMMA:	We need continued economic growth but we cannot live with the consequences.
THE CONTROL DILEMMA:	We need to guide technological innovation but we shun centralized control.
THE DISTRIBUTION DILEMMA:	The industrialized nations find it costly to share the earth's resources with less developed nations, but a failure to do so might prove even more costly.
THE WORK-ROLES DILEMMA:	Industrial society is increasingly unable to supply an adequate number of meaningful social roles. Legitimate social roles in an industrialized society are largely limited to (1) holding a job; (2) being married to someone who has a job; and (3) being a student preparing for a job. But the number of jobs provided by the system is only with great strain and artificiality brought close to the number of contributive roles needed.

To follow Harman's reasoning, a key characteristic of the future of U.S. society lies in the way in which we address these fundamental dilemmas. Some perceive that these dilemmas can be approached in such a way that a future of gradual change will evolve along the lines of Western culture to what has been termed a second-phase industrial state.[12]

A second group, whose leading spokesperson is Harman himself, perceives that our industrial society, faced simultaneously with with all the problems generated from the dilemmas, will transform itself into something different. This will probably involve a wrenching and traumatic transition period. Harman, in fact, foresees a simultaneous conceptual and institutional revolution proceeding with such rapidity that the most crucial period will be passed through within a decade.

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[12] This perspective is most cogently described in the work of Herman Kahn and his Hudson Institute colleagues. See, for example, Herman Kahn and B. Bruce-Briggs, Things to Come, Thinking About the 70's and 80's (New York: MacMillan Co.), 1972.

It is impossible at the present time to ascertain the accuracy of Harman's view or of any other. What is important to recognize is that the future very probably will be substantially different from the present. One of the things that can be anticipated, in addition to gross-level employment shifts, is a different institutional/organizational configuration with significant employment implications.[13]

a. Emerging Perspectives of Work

In a discussion of projected cultural changes, it is important to note changing notions about the nature and function of work itself. According to Harman's analysis mentioned above, the work-role dilemma is one of the four fundamental dilemmas comprising the current world macroproblem. And, as Harman adds, it is perhaps the most serious of all because we have so effectively concealed from ourselves its frightening dimensions relative to individual self-respect, effective citizenship, and national stability.

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[13] For a discussion of the relationship between resource use and technological change and implications for change in areas such as human resource utilization, education, business, and the information process itself, see John McHale, "Resources Available and Growth," in U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns, vol. 4: Resources and Energy, prepared for the use of the Joint Economic Committee, U.S. Government Printing Office (November 1976). For a discussion of anticipated employment changes at the industrial and at the individual firm level, see John P. Blair and Gary Gappert, "The Problems and Consequences of a Slow/No Growth Economy," in U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns, vol. 5: The Steady State Economy, prepared for use of the Joint Economic Committee, U.S. Government Printing Office (December 1976).

The impetus for emerging perspectives of work comes from different interest groups and disciplines and is reflected, for example, in the "...as if people mattered" work of E.F. Schumacher. He proposes consideration of the Buddhist point of view, which describes a threefold function of work:[14]

- to give a person a chance to utilize and develop his or her facilities;
- to enable people to overcome their ego-centeredness by joining with other people in a common task;
- to bring forth goods and services needed for a becoming existence.

Appropriate technology--with its concern for appropriate means, scale, and technology--has been suggested as an optimal context in which to nourish and satisfy these and other optimal functions. In a study entitled "Right Livelihood, Work and Appropriate Technology," the authors point to the necessity of differentiating between jobs and earning a living, and of changing our thinking from jobs to livelihood, from livelihood to right livelihood, defined personally and experienced as "living-in-place."[15] "Right livelihood," they continue, "...occurs at the nexus of your desires and your means of livelihood: when these are in balance and integrated, right livelihood appears to you."[16]

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[14] E.F. Schumacher, Small is Beautiful: Economics as if People Mattered (New York: Harper & Row, Publishers), 1973, pp. 54-55.

[15] Jerry Yudelson and Lynn Nelson, Right Livelihood, Work and Appropriate Technology, Report to the California Office of Appropriate Technology, Environmental, Berkeley, CA (September 1976), p. 10.

b. Employment Trends and Their Implications

Images of actual employment trends can be derived through examination of particular future scenarios, as well as from studies addressing anticipated cultural changes. The Energy Policy Project of the Ford Foundation, for example, in a study on America's energy future, constructed three different versions of possible energy futures through the year 2000. The three future scenarios, Historical Growth Scenario, Technical Fix Scenario, and Zero Energy Growth Scenario, were generated to help test and compare the consequences of different policy choices. An analysis of each in terms of variables such as energy use, income, and employment is provided. The general conclusions related to employment predict that:[17]

- energy conservation in the most energy intensive manufacturing industries will have little, if any, adverse effect on employment in these industries;
- growth in the labor force is expected to slacken after 1980 because of the slowdown in population growth;
- the United States can grow and prosper and have plenty of jobs--and still conserve energy.

Other future-oriented studies, such as "Alternative Futures for Environmental Policy Planning: 1975-2000," examine a wider range of driving trends and aspects, which makes it more difficult to extract an employment image unless one is familiar with the composite elements.[18] Certain categories such as technology, resources, and industrial development, are particularly relevant indicators from which to extrapolate probable employment trends and configurations.

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[16] Yudelson and Nelson, Right Livelihood, p. 10.

[17] Energy Policy Project of the Ford Foundation, A Time to Choose, America's Energy Future (Cambridge, MA: Ballinder Publishing Co., 1977), pp. 131-151.

2. Societal Issues that Influence the Energy/Environmental Field

In addition to identifying trends within the larger societal context that will influence the energy/environmental field, another important area to explore is current energy/environment employment-related issues. The most central of these issues addresses three interrelated aspects of economic growth, energy use, and the environment. Much attention has recently been given to this complex issue, and a brief description of the sub-issues is presented below.

a. Energy Use and GNP

This issue revolves around what might be referred to as the energy growth and prosperity myth, which addresses the relationship between energy use, gross national product (GNP), and social welfare or well-being. Public understanding of this relationship has been that energy expansion has been the basis for and impetus to economic growth, the "good life."

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[18] Duane S. Elgin; David C. MacMichael; and Peter Schwartz, "Alternative Futures for Environmental Policy Planning: 1975-2000," Stanford Research Institute, Stanford, CA, October 1975. (Prepared for Environmental Protection Agency, Contract #68-01-2698).

and jobs.[19] Events of the past decade or so, however, have shown that this relationship is not as linear or as intimate as has been portrayed. Studies have been conducted on ways to stimulate economic growth under different energy supply-and-demand conditions (e.g., the previously-mentioned Ford Foundation Policy Project).[20] The resultant growth paths have shown that reduced energy use can indeed be accomplished within the current economic structure without major economic upheaval or collapse. Indeed, it can have a stimulating effect on employment and cash flow. Numerous other organizations and analysts, in their attempts to unravel the role of energy and its relationship to the rest of the economy, have also concluded that an ever-increasing energy consumption per capita is not a prerequisite to increasing economic growth.[21] As Hazel Henderson points out: "Today, we stand largely aware of the fact that the GNP is not (and in all fairness to its inventor, Simon Kuznets, was never intended to be) an overall measure of human welfare."[22]

Since GNP is an aggregate measure, it is not sufficiently refined and differentiated to be used as the sole basis for measuring the health of our industrial system. GNP, at the gross level, represents primarily an accounting of external costs rather than internal costs and environmental impacts of industrial production. Consequently, relying solely on GNP leads us away from knowing true costs and wealth.

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[19] Richard Grossman and Gail Daneker, JOBS AND ENERGY (Washington, D.C.: Environmentalists for Full Employment), 1977.

[20] Energy Policy Project of the Ford Foundation, A Time to Choose: America's Energy Future (Cambridge, MA: Ballinger Publishing Co.), 1974.

[21] For a discussion of additional studies that have examined this relationship, see Grossman and Daneker, JOBS AND ENERGY, pp. 3-4.

[22] Hazel Henderson, "Redefining Economic Growth," p. 127.

Related concerns regarding actual energy use and quality of life considerations have been addressed primarily through comparative energy use studies. The United States, for example, spends nine times as much as the world average on its "needs" --health, food, education, shelter, military, etc., and definitely more than any other country. Yet indicators such as longevity, unemployment, divorce, and crime reflect a relatively low quality of life compared to other countries. Energy use figures in European countries such as France, Sweden, and West Germany, indicate in fact that a higher quality of life is possible with a much lower energy use than ours.[23]

b. Energy Use and Jobs

A second myth surrounding the issue of economic growth, energy use, and the environment has been articulated in terms of "more energy leads to more jobs."[4] The basis of this myth lies in the fact that accompanying our growing population there has been a very large increase in the use of goods and services per person and a significant increase in energy use. It has thus appeared as if energy expansion has been the primary causal factor in economic expansion and the increasing number of jobs generated. But because the trend has been for industry to substitute energy for labor, it is more accurate to view the situation in terms of the consistently expanding demand that has led to consistently expanding production. As more and more energy is substituted for labor, automation increases and the total number of workers needed decreases. What is therefore critical to examine in relation to employment implications are demand factors rather than figures restricted to energy use or power production.

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[23] Yudelson and Nelson, Right Livelihood, Work and Appropriate Technology, pp. 74-78.

[24] Grossman and Daneker, JOBS AND ENERGY, p. 2.

Another way to explore this relationship is through looking specifically at employment growth and energy use in various industries. Between 1950 and 1970, for example, the five largest manufacturing industries experienced no employment growth, yet their gross energy consumption increased greatly.[25] During this same time period jobs increased in the energy producing industries only 5.5% while total national employment increased 41%.[26] Overall, the major energy-producing and energy-using industries consume one-third of the nation's energy, yet they directly provide only about 10% of the nation's jobs.

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[25] Grossman and Daneker, JOBS AND ENERGY, p. 2.

[26] It is interesting to note that the small increase during this twenty year period was due primarily to expanded gasoline station employment and most of these jobs are now vanishing, being replaced by self-service facilities.

Yet anther facet of this energy use/job relationship can be explored through energy use and labor intensity associated with various personal consumption activities. This perspective enables one to see how industrial demands and subsequent expenditures ultimately influence employment configurations.[27] Examining first the energy and labor intensities of various production activities, one sees that, with respect to energy use, labor intensive activities are concentrated in such areas as health care, hotels, and crafts. And, with respect to employment, energy intensive activities are in the primary production areas of steel, rubber, chemicals, plastics, etc. Working from this information base, it is then possible to trace at quite a specific level how (and what) changes in individual consumption patterns influence the number and nature of jobs created or eliminated.

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[27] A great deal of information pertinent to this can be derived from work completed by the Energy Research Group at the University of Illinois Center for Advanced Computation. See, for example, Bruce Hannon, "Energy, Labor, and the Conserver Society," Technology Review, 79:5 (March/April 1977).

D. AN INTEGRATIVE FRAMEWORK FOR ENERGY/ENVIRONMENTAL CAREER DECISION-MAKING

The amorphous, changing nature of the energy/environmental field can be appreciated in view of this brief examination of contextual and relational aspects. In attempting to correlate this more dynamic dimension with the commonly held and narrowly defined perception of the energy/environmental field outlined earlier, it becomes evident that some metastructure or framework is needed to integrate all aspects. Such an integrative structure per se is not currently available to use or adapt. What follows is a proposed design for such a framework which, if developed, will enable individuals involved in making decisions about energy/environmental related careers to, among other things:

- assess employment implications of energy/environmental related issues;
- consider lifestyle implications associated with various careers;
- locate/identify the impact potential of a career.

Figure 2 presents a framework designed in the form of a matrix; one axis represents a dynamic, comprehensive image of the energy/environmental field, while the other portrays important aspects to be considered in relation to particular careers.

The proposed schema for portraying the structure and processes of the energy/environmental field is presented in terms of resource delivery systems. Such a tool enables one first to delineate the resource and technological means to satisfy the demands of society and then to analyze the "efficiency" of a particular system.[28] Resource

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[28] "Efficiency" is broadly measured in terms of net energy, energy quality, and end use.

Career Aspects / Resource Delivery Systems	Relationship to EE Problem/Issue	Influencing Potential	Energy/Labor Intensive	Environmental Impact	Physiological and Psychological Hazards	Future Status Influencers	Transferability	Associated Lifestyle
EXPLORATION								
EXTRACTION								
TRANSPORT I								
PROCESSING								
TRANSPORT II								
CONVERSION								
DISTRIBUTION								
END USE								

Figure 2. A SCHEMA FOR ENERGY/ENVIRONMENTAL CAREER RELATED DECISIONS

delivery systems are organized into eight generic processes or stages, which are outlined on the following pages. The use of such a process-oriented structure provides a means, for example, for assessing implications of proposed energy/environmental policies. This dynamic schema, as it is applied to the full range of current and potential renewable and nonrenewable resources, facilitates the assessment, monitoring, and comparison of policy dimensions such as the following:

- the nature and net number of jobs affected by different technologies, proposed conservation measures, proposed environmental protection restrictions, etc.; and
  - . on which resource are they dependent?
  - . at which delivery stage?
  - . which types of jobs are affected--skilled or non-skilled?

The vertical axis of Figure 2 consists of the eight resource delivery system processes that provide the basis for this type of anticipative analysis. A description of each of these processes is presented below, along with a brief description of associated activities:

1. EXPLORATION:
   siting of resource deposits, basic research and development of exploratory techniques, machinery.
2. EXTRACTION:
   removing the resource; machinery and site equipment; materials; operating agencies; maintenance over the life of site.
3. TRANSPORT I:
   transportation mechanisms and operating energy necessary to carry the resource to the next facility.

4. PROCESSING:
   energy to run machinery; construction of the facility, its maintenance and operating energies.

5. TRANSPORT II:
   transportation systems and the operating energies required to move the resource to the conversion plant.

6. CONVERSION:
   plant construction, materials, and maintenance.

7. DISTRIBUTION:
   energy costs, equipment, storage facilities, and networks to move the converted product fron final facility to point of consumption.

8. END USE:
   directed to satisfying "basic human needs," i.e.,
   - shelter
   - communications
   - organizations (political, financial, legal, special interest, etc.)
   - education (curiosity and knowledge)
   - physical protection (health)

The horizontal axis of Figure 2, which represents career and lifestyle related variables to be considered, consists of the following aspects:

- Relationship to key or central energy/environmental problem or issue areas such as population dynamics, pollution, resource allocation and depletion, conservation, transportation, and technology:[29]
    - directly related;
    - indirectly related.
- Influencing potential:
    - to what aspect of problem/issue;
    - nature of the influence;
    - opportunity for using transdisciplinary problem-solving and decision-making skills to address problems/issues.
- Energy/labor intensive ratio of job.
- Environmental impact of career-related activities:
    - individual level;
    - aggregate level.
- Physiological and psychological hazards associated with career.
- Major factors influencing future status of career.
- Transferability (generic nature) of skills.
- Energy-intensive nature of associated lifestyle.

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[29] These key areas of concern to the energy/environmental field were derived from the Environmental Education Act. Additional areas to consider are: urban and rural planning, environmental quality, ecological balance, economic and technological development, and environmental ethics.

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HOLISTIC
LIFESTYLE
ASSESSMENT

A. INTRODUCTION

People, organizations, and societies chart their courses and judge their successes based on subjective factors (such as happiness) as well as objective factors (such as material wealth), both of which are reflections of prevailing value systems. Implicit in all value systems are assumptions and beliefs concerning the nature of reality and the way the world works. The harshness or security of an environment and the abundance or scarcity of goods all affect the field of choices that will be culturally perceived as "good," or even possible, choices. These values/choices are sometimes merely "culturally' reinforced, and sometimes more directly reinforced. (Direct reinforcement includes such things as depletion allowances and freight rates that encourage the use of virgin materials over recycled materials).

Our assumptions about how our world works have been changing over the last decade or two, reflecting a growing awareness of the following things: (1) the limits of easily available energy sources; (2) the limited capacity of the natural environment to accept the perturbations and residues of human activity;[1] and (3) the continuing social inequities within and between nations.[2]

Prevailing values must shift to reflect these limits, and personal and social choices must begin to reflect new values. This shift in values is presently occurring, to some extent in the form of individual assumption of new values, largely for subjective reasons (e.g., the recycling of bottles and cans because "it's good for the environment"). This shift is also motivated by economic factors, such as the rise in fossil fuel costs in relation to solar energy, or the new economic pressures resulting from recent regulatory action.

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[1] Eric Eckholm, Losing Ground (Norton, 1975).

[2] Jan Tinbergen, RIO: Reshaping the International Order, (New York: Dutton, 1977).

The right decisions may be clear in some cases, but in other cases they are not. Some decisions are particularly complex--especially those that must be made by a national government or a large corporation--and may require a mechanism for weighing the diverse components of that complexity. Money has long served as a common denominator, but has not dealt well with unpriced value, such as the "free work" provided by the environment.

Apparently wise decisions may even have counter-intuitive implications. A consumer's decision to bicycle rather than drive to work in order to save energy could actually wind up costing society energy, if the money saved by the conservation action winds up--as it often does--spent on some other energy-intensive activity.

Control of behavior in natural systems has developed over millions of years of evolutionary experience. Certain responses have become "pre-wired" in each organism, and relationships among organisms in an ecosystem have themselves evolved in response to changing conditions. Such controls may be "hard-wired," in the sense of being coded into the genetics of the organisms, or "soft-wired" in that they are products of the relationships of ecosystem components.[3] In either case, these systems act without will or self-awareness, yet the control patterns exist. For example, H.T. Odum observed changing patterns of energy use and energy efficiency among organisms in ecological successions.[4] At early stages in the succession -- e.g., the new growth of meadow following a forest fire -- organisms that can capture and utilize large amounts of energy (which is then easily available) are favored. As the succession evolves and competition for energy and other resources becomes more severe, the organisms that make the most efficient use of those resources will be most successful.[5] In any successional sequence, one can observe in the early stages a preponderance of energy-profligate organisms, and an emphasis on productivity. In the later stages, there is a preponderance of energy-efficient organisms, and an emphasis on maintenance.[6]

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[3] Gregory Bateson, Mind and Nature (New York: Dutton, 1978).

Such a transition to "late succession" behavior is what many have sought from contemporary energy policy.[7] But social systems, unlike natural systems, lack hard-wired, short-term controls to effect the same inevitable shift from high to low energy use. Hard-wired controls no doubt exist in the long term, and could be quite costly if a society unprepared for the transition suddenly had to confront greatly reduced availability of essential resources. But social systems are also unlike natural systems in that they have the potential for self-awareness, for conscious choice among the alternatives. They may choose to use that capability, or they may allow the choices to be made for them by the more expensive long-term reactive ecosystem processes.

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[4] H.T. Odum, Environment, Power and Society (New York: Wiley, 1971).

[5] Ramon Margalef, Perspectives on Ecological Theory, University of Chicago Press, 1968.

[6] See, for example, Amory Lovins, Soft Energy Paths: Toward a Durable Peace (Cambridge, MA: Ballinger Publishing Co., 1977).

[7] Lee Schipper, "Hidden Benefits of Conservation."

Some mechanism is needed then, to provide a relatively universal guide to decisions involving resource use. There have been attempts to incorporate "whole system costs" into economic prices, but, as the natural environment does not measure anything in money, and money does not measure everything, these approaches have become arbitrary and unwieldy.[8] Also, in these times of currency devaluations, dollar prices may not be the most meaningful guide for people to utilize. For these reasons, and others, accounting in energy terms has been proposed as a more valid and more useful common measure.

As convenient as single standards may seem, there are limits to the application of any standard that depends on the purposes for which the standard is being used. The Gross National Product is the main standard that has been used by modern societies, but with increasing dissatisfaction. As with all aggregate measures, the GNP can not differentiate between different kinds of production or investments, nor what goods and services they produce, nor what sorts of jobs were created in the process. Any intelligent citizen could see that the underlying economic signalling system is no longer sufficiently refined and differentiated to program economic activity with the level of rationality needed to manage the vast complexities of a modern industrial economy.[9]

Economists have attempted to broaden the scope of the GNP by modifying it to incorporate social variables, as well as strictly economic ones. Measures such as Net National Welfare (NNW) and Measure of Economic Welfare (MEW) have not found ready acceptance as yet in the United States, although NNW is being adopted as a planning tool in Japan.[10] These new efforts (to improve the GNP and devise new social indicators of human welfare) underline Charles Cicchetti's observation that an economic signalling system that rewards activities with individual or corporate profit in spite of the unaccounted social and environmental losses they incur must be overhauled with vastly greater information about these losses. It was Kapp's central thesis (in Social Costs of Private Enterprise, 1950) that the maximization of net income by microeconomic units (entrepreneurs, corporations, etc.) was likely to reduce the income or utility of other economic units and of society at large, and that conventional measures of the performance of an economy were misleading. Interestingly, Jay Forrester (in World Dynamics, 1971), translates this statement into an axiom concerning the behavior of large non-linear systems: the optimization of any given subsystem will generally be in conflict with the goal of optimizing the macrosystem of which it is a part.[11] But the energy basis of value offers many insights that purely economic assessments may miss. Energy, unlike money, is physically measurable. Money, while a valuable tool precisely because of its abstract nature, is in no way directly linked with physical reality.

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[8] See, for example, Fisher, Krutilla, England and Bluestone, "Ecology and Social Conflict" in Herman E. Daly, ed., Toward a Steady State Economy (San Francisco: W.H. Freeman & Co., 1973), pp. 190-214.

[9] Hazel Henderson, Redefining Economic Growth, pp. 125-126.

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[10] Henderson, in J.N. Smith, ed., Environmental Quality and Social Justice in Urban America (Washington, D.C.: The Conservation Foundation, 1974).

[11] Henderson, Redefining Economic Growth, pp. 127-128.

> Energy flows are believed to be the basis for organization of matter, money, information, and value. Therefore, energy analysis for whole systems can show quantitatively which alternatives generate the most productivity and value. Since energy principles apply to all sizes of systems, energy methods apply analysis equally to all systems of life, environment, cities, regions, nations, or the biosphere as a whole.[12]

Energy accounting, unlike economic accounting, requires a holistic approach by its very nature. Referring to economist Nicolas Georgescu-Roegen's application of the Second Law of Thermodynamics to economics,[13] Hazel Henderson observes:

> One implication of the entropy law is that all economic processes must be modelled in their entirety, from extraction to fabrication to distribution to consumption to waste to recycling. This is necessary to pinpoint any hidden energy subsidies along the way, and compare the energy efficiency of each part of the production cycle.[14]

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[12] H.T. Odum, "Net Energy Analysis of Alternatives for the United States," in Middle- and Long-Term Energy Policies and Alternatives, Part 1, Subcommittee on Energy and Power, House Interstate and Foreign Commerce Committee, Serial No. 94-63 (March 25-26, 1976), p. 257.

[13] Nicolas Georgescu-Roegen, "The Entry Law and the Economic Problem," in Daly, Steady State Economy, pp. 37-49.

[14] Henderson, Hazel, "Ecologists versus Economists," Harvard Business Review, July-August 1973, (and Middle- and Long-Term Energy Policies and Alternatives, Part 3, p. 17.)

B. WHOLE SYSTEM HEALTH

The process of Holistic Lifestyle Assessment provides a basis for considering the impact of human activities in real energy terms, and for describing and assessing the overall impact of human activities on self, society, and environment. It is a relatively new tool, an attempt to develop an integrative decision-making process that may be more accurate than strictly economic measures, and more sensitive to environmental realities. It can serve as a measure of both personal and social health, and as a guide to future actions and lifestyles.

At its broadest, Holistic Lifestyle Assessment includes a wide variety of strategies, including analytical approaches (such as energy accounting), qualitative approaches (such as the wellness inventory), and mixed approaches (such as social impact assessment). We have a particular interest in the energy-based approaches, but will consider the broader set here. All are fundamentally linked in that they attempt to bring a greater understanding of whole system impacts into otherwise fragmented decision-making processes. Each assessment, by whatever technique, requires a delineation of the inputs, throughputs, and outputs of energy and materials that support a given lifestyle or process. The assessment must consider both the direct and the indirect energy costs and social costs of each activity or product, and it must consider the relative importance of each activity or product in meeting needs and desires. It should also consider the energy and social impact of either (1) using different activities and/or products to meet given needs and desires; or (2) redefining needs and desires in a variety of ways to change their impacts.

All these factors, taken together, are considered in the larger goal of assessing the effect of the activity under consideration on the health and flexibility of the entire system.

A major tenet of ecological thought, indeed of systems thinking in general, is the interconnectedness of the components of complex systems. Interaction with one component of the system will affect other, if not all other, components in ways that may or may not be predictable. As Barry Commoner states so simply in his oft-quoted "Laws of Ecology"--"you can't do only one thing."

Nevertheless, we persist in trying to "do only one thing." Our civilization still largely believes in a mechanistic rather than an ecological model of how the world works. We persist in attempting to apply relatively simple solutions to complex problems, trying vainly to solve one part of the problem at a time. This may be out of ignorance of the fact that complex interconnections exist, or ignorance of their precise nature. In either case, such an approach can be at best ineffective, and at worst, dangerous.

> ...all ad hoc measures leave uncorrected and deeper causes of the trouble and, worse, usually permit those causes to grow stronger and become compounded. In medicine, to relieve the symptoms without curing the disease is wise and sufficient if and only if either the disease is surely terminal or will cure itself.[15]

Few would maintain that the ills of modern civilization will cure themselves,[16] and certainly all of us hope the disease is not terminal. We are therefore left with the option of evolving wiser ways of dealing with complex systems, an evolutionary process that includes three components: 1) accepting (and educating others to accept) the importance and validity of the whole systems approach; 2) learning to monitor whole system health; and 3) developing multifaceted strategies for dealing with complex phenomena.

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[15] Gregory Bateson, "The Roots of Ecological Crisis," in Steps to an Ecology of Mind (NY: Ballentine Books, 1972), pp. 488-489.

[16] For an alternative opinion, See Herman Kahn, et al., The Next 200 Years (New York: William Morrow and Co., 1976).

The first and third components are dealt with in other portions of this sourcebook. Holistic Lifestyle Assessment can make an important contribution to our ability to monitor whole system health, and can be used as a means to apply personal and collective strategies to lengthening the health of the longer system.

There are several ways of understanding ecosystem health that may, by extension, be useful ways of looking at the health of other systems--including such parameters as stability, resilience, and flexibility; but perhaps the most elegant and useful is the concept of adaptation:

> The process by which living systems maintain homeostasis [See Glossary] in the face of both short-term environmental fluctuations and, by transforming their own structures, through long-term, non-reversing changes in the composition and structure of their environments as well.[17]

Both as individuals, and as a society, we face a constantly changing world. Some changes (such as the seasons) are regular, cyclical, and ancient, and species and cultures have accommodated to them from their earliest appearance. Other changes proceed so slowly--geological transformations, long-term climatic patterns--that they need not be taken into account in daily life, or even in a lifetime. On the other hand, the rate of change during the twentieth century has been unprecedented in human history, both in its degree and its pace (and its seeming refusal to let up).[18] The extent and speed of changes in, to name just a few areas, speed of transportation, range of communication, and personal energy expenditures is truly awesome for such a short period of time. And, as indivuals and as a society, we have "adapted" to those changes. But adaptation is not always adaptive, for at least three reasons.

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[17] Rappaport, Roy, "Energy and the Structure of Adaptation," CoEvolution Quarterly (Spring 1974), p. 22.

First, both the pace of change, and many of the features of modern society themselves, produce stress in individuals and in institutions.

Second, learning to "get along" with the processes that produce stress and its associated disorders may not be the wisest response to the modern world. As Roy Rappaport explains, steps that:

> ...contribute to the maintenance of orderliness and the reduction of anxiety without contributing to the correction of the factors producing the anxiety and disorder are not adaptive but pathological.[19]

"Getting along" with stress is likely to seem easier in the long term than relieving the causes of the stress. Relieving the stress, or even some of the causes--assuming people can agree on what they are--can seem an enormous undertaking. It is an enormous undertaking. But, "getting along" with stress is often a matter of delaying or denying, rather than escaping, the physiological, psychological, ecological and social results of stress.

Sometimes the process of "getting along with stress" is external--developing varieties of street trees that are resistant to pollution eliminates the early warning function the trees serve for humans, who cannot adapt as rapidly. The process may be internal--for example, screening out continuous noise or learning not to tense up in its presence may help someone work in a noisy environment, but may not protect the person from physiological damage induced by the noise.

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[18] Alvin Toffler, Future Shock (New York: Random House, 1970).

[19] Roy Rappaport, "Sanctity and Adaptation," CoEvolution Quarterly (Summer 1974).

Third, the process of "getting along" may have its impacts on the flexibility of the system as a whole. The "new realities" to which we have adapted are themselves changing, and while perhaps not as rapidly as before, they are shifting in directions unanticipated by the common wisdom of previous decades. The outstanding example of this effect, of course, is the changing energy picture. We have set in place so much structure based on expectations of abundant and cheap energy resources that we cannot respond quickly to the changing realities. We have purchased convenience at the cost of the ability to respond to change and we may pay a steep price to regain the flexibility.

> ...any biological system, (e.g., the ecological environment, the human civilization, and the system which is to be the combination of these two), is describable in terms of interlinked variables such that for any variable there is an upper and lower threshold of tolerance beyond which discomfort, pathology, and ultimately death must occur. Within these limits, the variable can move (and is moved) in order to achieve adaptation. When, under stress, a variable must take a value close to its upper or lower limit of tolerance, we shall say, borrowing a phrase from the youth culture, that the system is "up tight" in respect to this variable, or lacks "flexibility" in this respect.
>
> But, because the variables are interlinked, to be "up tight" in respect to one variable commonly means that other variables cannot be changed without pushing the "up tight" variable. The loss of flexibility thus spreads through the system. In extreme cases the system will only accept those changes which change the tolerance limits for the "up tight" variable. For example, an overpopulated society looks for those changes (increased food, more roads, more houses, etc.) which will make the pathological and pathogenic conditions of overpopulation more comfortable. But these ad hoc changes are precisely those

which in a longer time can lead to more fundamental ecological pathology.[20]

Relieving the causes of the personal and ecological stresses of industrial civilization will require wisdom as well as will. To avoid repeating the same class of problems, however well-intentioned our attempts (those who made the mistakes of the past were no less well-intentioned), it will be necessary to have a fuller understanding of the interconnections and dynamics of complex systems. Decision analyses will have to reach far into the future, and broadly across many aspects of society, to uncover (in advance) the implications of one course of action and its advantages or disadvantages in relation to another. People in their every day choices clearly cannot take the time to conduct that kind of anticipatory planning, but their choices can reflect such planning. Integrative tools that sum up the results of such broad analyses may make it easier to place tools of anticipatory, comprehensive planning in the hands/minds of each worker, consumer, and decision-maker.

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[20] Bateson, Gregory, "Ecology and Flexibility in Urban Civilization," in Steps to an Ecology of Mind (New York: Ballantine Books, 1972), pp. 496-497.

C. THE HUMAN SYSTEM

We can think of the human system as an open system, characterized by particular inputs, throughputs (or processes), and outputs. Depending on our purposes, we can define that system at different levels--the individual, the household, the neighborhood or city, the society as a whole. At each level we can identify inputs, throughputs, and outputs; they may not, however, be the same ones at each level. For example, outputs at one level may be inputs at another level.

Consider a single individual. Inputs include food, water, air, energy (heat, electromagnetic radiation), shelter and clothing, and information (culture, social interaction). Throughputs include biochemical processing of raw materials and depreciation or wear and tear of goods and thought processes. Outputs include bodily growth, physical waste products, heat, noise, maintenance work, creative work, information. Many of these items are objectively measurable, while some are subjective, or even abstract.

Each of these many inputs and outputs have inputs and outputs of their own, often beyond the boundaries of the system we may be primarily concerned with (for system boundaries always reflect some degree of convenience and arbitrariness). One must balance the need for a system large enough to include all relevant components with the need for a system compact enough to permit the development of the necessary level of resolution and detail. From a single input, like a wool sweater, we can trace a long path of materials and processes: the distribution system through which the sweater was sold; the factory where it was made; the ranch at which the sheep were raised; perhaps the farm at which their feed was grown; plus the transportation systems that moved materials between these components; plus another layer of inputs into each of these components. A single output, be it a bag of garbage or a good day's work, likewise has effects that ripple throughout the system and beyond its boundaries.

Each of these components of the human system--inputs, throughputs, outputs--meets real or perceived human needs. Each may have implications for energy and material use, environmental quality, social patterns, employment, health, and ranges of future choice. The challenge of what we are calling HLA, or of any attempt to develop an integrating tool for guiding complex decisions, is to (1) identify key factors; (2) create a mechanism for comparing dissimilar, or even non-quantifiable factors; and (3) reduce the mass of data to comprehensible and easily manageable form, without loss of critical information and detail.

As discussed earlier, one feature that unites the diverse components of the human system, and of all systems, is that all have associated energy costs--energy that is applied in a particular way to fulfill a particular need. In a later section, we will explore other holistic assessment approaches that are not energy-based. For now, though, since energy forms the basis of this environmental education package, let us consider human needs and desires in terms of their energy costs, and the implications for HLA.

1. Human Needs

All approaches to HLA necessarily assume a relativism of human needs. If all "needs" were absolutely necessary, there would be no way to exercise choice among them. One can think, then, of a hierarchy of needs ranging from basic material subsistence through more subjective needs for fulfillment, etc. Within each level, there are different classes of needs as well. Certain needs are climate-specific, or primarily related to the surrounding natural environment. Natural environmental contexts have characteristics that generate as well as provide for some human needs. These characteristics vary in space and over time. One important characteristic is climate.

- Macroclimates are associated with the major geographic regions, such as mountains, deserts, major plains, and coastal areas. People, as well as other organisms, have developed strategies for dealing with the different climatic characteristics of these different regions.
- Microclimates are smaller scale variations associated with special variations in the local area such as: river beds, forests, foothfills, beaches or highlands.

Climate-specific needs are closely linked with these aspects of the physical environment. Housing form and clothing, organization of communities, and patterns of life have evolved differently in different regions to respond to "needs," as generated by the different climatic conditions. In a relatively obvious way, harshness of climate contributes to requirements for housing[21] and clothing. In a less obvious way, seasonal variations that limit the foodstuffs available or growable in an area, as well as cultural/environmental-specific needs, both have some affect on what foods people prefer to eat.

Cultural/environmental-specific needs are closely linked with the individual's understanding of his or her cultural environment--traditions, values, trends, etc. As with climate, two levels of cultural environments can be described:

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[21] See, for example, Victor Olgyay, Design with Climate: Bioclimatic Approach to Architectural Regionalism (Princeton University Press, 1963).

- Macrocultural environments include such traditional elements as ethnic group, subculture affiliation, religious affiliation, and newer components such as mass culture and mass media.

- Microcultural environments include such factors as urban or rural, old established family or tourist, and socioeconomic level. (As with the climatic factors, microcultural environments represent a finer texture of variation within the larger patterns set by the macrocultural environment.)

The interplay between these two levels generates very complex value systems in the individual. When this interplay is combined with an individual's migration, and exposure to an all-pervasive media, it renders distinct articulation of values very difficult. In fact, increased mobility and migration, together with the pervasive media and national and international markets, have contributed to an increasingly homogeneous macroculture that, many critics maintain, is beginning to reduce the significance of other variations in both the macrocultural and microcultural environments. Some identify this as a positive trend, conducive to greater prosperity and world unity[22] while others see it as negative, a loss of valuable cultural diversity and conducive to autocratic manipulation. It is acknowledged, in either case, to be a powerful influence.

> Today, as in the past, the relation that man bears to his total environment is influenced by values of which he is not always aware. A civilization that devotes page after page of its popular magazines to portraying the rulers of the business world is bound to produce men very different from those taught to worship Confucian wisdom, Buddhic mysticism, or Blake's poems--even if that worship often does not go beyond mere lip service. To feel at ease among the neon lights of Broadway demands a type of mind and body not conducive to happiness in the midst of a Taoist landscape. Technology is now

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[22] Herman Kahn, et al., The Next 200 Years.

> displacing philosophical and religious values as a dominant force in shaping the world, and hence human values.[23]

Needs can be differentiated in another way as well, one that may have more immediate relevance to the process of holistic life-style assessment. It is a more malleable differentiation, one that lends itself more readily to action and modification, yet still operates within the contexts set by the climatic and cultural environments. All people will recognize a distinction between "needs" and "desires," although people will disagree widely on how to make that distinction. Sometimes it is an obvious matter: an average American male adult may need 2500 calories, 54 grams of protein, and other nutrients in food each day, but he may desire an elegant French dinner with wine. Or, he may desire to be involved in strenuous physical activity that greatly increases his caloric need. But it is often less obvious, for the distinction has always been a moving target.

> Once his essential biological needs are satisfied, man develops other urges which have little bearing on his survival as a species. When he no longer needs to struggle for his loaf of bread he is wont to crave an unessential savory, then to long for some artistic expression. When he has established all kinds of direct and indirect contacts with the surrounding world he begins to worry about the next television set and soon longs to explore the rest of the universe. Indeed, it is probably the most distinguishing aspect of human life that it converts essential biological urges and functions into activities which have lost their original significance and purpose.[24]

While Dubos finds the roots of our rising expectations in human nature, Jerry Mander identifies a self-generating and reinforcing process occurring as an increasingly homogeneous macrocultural environment encourages still greater homogeneity through its "child and parent":

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[23] Rene Dubos, Mirage of Health, (New York: Anchor Doubleday, 1959), p. 221.

[24] Dubos, Mirage of Health, p. 225.

> The Inherent Need to Create Need
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> Advertising exists only to purvey what people don't need. Whatever people do need they will find without advertising if it is available. This is so obvious and simple that it continues to stagger my mind that the ad industry has succeeded in muddying the point. ...I have never met an advertising person who sincerely believes that there is a need connected to, say, 99 percent of the commodities which fill the airwaves and the print media. Nor can I recall a single street demonstration demanding one single product in all of American history.
>
> The goal of all advertising is discontent or, to put it another way, an internal scarcity of contentment. This must be continually created....newly purchased commodity must be gotten rid of and replaced by the "need" for a new commodity as soon as possible. The ideal world for advertisers would be one in which whatever is bought is used only once and then tossed aside. Many new products have been designed to fit such a world.[25]

One goal of Holistic Lifestyle Assessment is to enable us to fine tune our lifestyles and consumption patterns to the emerging reality of a world with finite resources and increasingly expensive energy, or to other criteria we may choose. In order to meet this goal, the process of need generation, and differentiation of needs and desires, must become explicit. There is nothing unusual, or necessarily wrong, with a self-reinforcing value system. In many ways it is the norm, and can perhaps be better understood by defining the attitudes and values of an individual (and hence a culture) as a "fuzzy set system"--or worldview--consisting of:

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[25] Jerry Mander, Four Arguments for the Elimination of Television (New York: William Morrow and Co.), 1978.

- inputs, in the form of cultural heritage, customs, and social norms acquired through early childhood and family interaction;
- "throughputs," in the form of current attitudes and values development reinforced through culture, peer interaction, and migration;
- outputs, in the form of maintenance and continuance of existing worldview through present decisions to satisfy future desires.

The decisions that are the output of this system establish the momentum of an individual's personal performance in career and lifestyle. As they are fed back, million-fold, into the input and throughput stages of each person and those he or she contacts and influences, they establish the momentum for the values and development of the society as well.

As we begin to apply tools like HLA in an effort to make that feedback process conscious and responsive to emerging environmentally sensitive values, we would do well to keep in mind "An Apparently General Law of Transformation: All transformation processes [what we call here 'throughputs'] involve the production of an intended output and unintended byproducts."[26] What are the unintended byproducts in the process we have been discussing?

2. Needs and Energy Costs

All human needs, and all human desires, whether culture- or climate-specific, have associated energy costs. These energy costs may be large or small, and in some cases nearly infinitesimal, but they are always there for the tracing. As they are traced, it becomes possible to make choices regarding how--or whether--to fulfill particular needs in ways that make the wisest possible use of energy resources.

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[26] Kimos Valaskakis, Peter S. Cindell, J. Graham Smith, eds., The Selective Conserver Society, vol. 1 (Montreal: GAMMA, 1978), p. 26.

Table 1 presents a range of human needs, and for each need a number of means for satisfying that need. Note that while the necessity of each category should be fairly clear, the means of satisfaction can vary widely, including activities traditionally understood to meet that need, as well as less traditional activities.

The means of satisfaction of each need not only reflect the cultural and climatic contexts within which the need is manifested, but the means of satisfaction themselves represent a wide range of energy requirements. Clearly, there are different direct and indirect energy costs associated with meeting recreation needs by motorcycle riding, or going to a movie, or walking in the park, or walking in the woods. Until recently, people have not taken energy costs into account in making such selections, relying solely on personal preference (conditioned, as we have seen, by cultural and climatic contexts).

The cultural context has skewed such preferences in the direction of increased energy use in human activities. This can be seen in a particularly dramatic way by comparing energy use of families at different income levels. Herendeen has found that high-income families--those in a financially better position to act on their preferences--account for considerably more energy use than do

NEED	MEANS OF SATISFACTION
Residential Shelter	Furniture, Lighting, Appliances, Heating, Cooling, Water Supply Landscaping
Organizations	Government, Political, Financial, Labor, Service, Special Interest Groups, Professional, Social, Legal
Creativity and Recreation	Sports, Entertainment, Toys, Pets, Arts and Crafts, Alcohol and Drugs
Food	Meats, Vegetables, Dairy, Fruits, Grains, Bakeries
Communications	Telephone, Radio, TV, Books, Talk, Magazines, Postal
Physical Protection	Police, Fire, Military, Health
Apparel and Grooming	Cosmetics, Clothing, Hair
Curiosity and Knowledge	Schools, Libraries, Museums
Spiritual	Churches
Birth and Death	Maternity, Babywear, Funeral Parlors
Mobility	Cars, Buses, Airplanes, Highways

Table 1. HUMAN NEEDS ASSESSMENT

low-income families.[27] This energy consumption is of two types. Direct energy use (involving purchases of energy or energy-providing materials--electricity, heating oil, gasoline) appears to level off at a net income of about $10,000, while indirect energy use (the energy embodied in all goods and services), continues to rise with income. At the highest income levels, about two-thirds of energy use is indirect. At those levels, energy conservation strategies that are aimed at direct energy use will miss the major portion of their energy consumption impact.

The relation of needs and energy also touches on issues of convenience and leisure. We seek easier, quicker ways to do things, with the expectation of thereby gaining a little more leisure. But "convenience demands energy," as Bruce Hannon explains. "Giving up convenience is the equivalent of the consumer accepting a lower implicit wage, and saving energy."[28] Convenience may require other trade-offs as well--TV dinners versus home-cooked meals, for example--while the net benefits are debatable. A study by Ralph Nader and Beverly Jones several years ago found that the average housewife spends, on an average, as many hours a day managing the home as her counterpart did fifty years ago, although the mix of activities has changed. All in all, some would question whether our drive for convenience has in fact gained us more leisure. A number of anthropological studies have found that "primitive" hunter/gatherer societies often have *more* leisure time per person than industrialized societies, even though our common wisdom imagines them with less.[29]

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[27] R.A. Herendeen, "Affluence and Energy Demand," *Mechanical Engineering* (October 1974), pp. 18-22.

[28] Bruce Hannon, *Energy, Growth, and Altruism* (Urbana, IL: Energy Research Group, Center for Advanced Computation, University of Illinois, 1975).

> The increase of consumption time at the expense of free time is both a loss and a gain. Here we encounter a subtle, complex problem. Increased consumption may add excitement and pleasure to what would otherwise be considered boring time. On the other hand, this increase has the effect of crowding time with consumption so that people begin to feel that "time is short"--which may detract from the enjoyment of consumption.[30]

Moreover, the very act of providing for the increased consumption, convenience, and apparent leisure may take its toll in time. Ivan Illich maintains that, "Beyond a critical threshold, the output of an industrial society established to move people costs a society more time than it saves."[31] Illich calculates the time a wage earner might spend supporting an automobile, and compares that with the time spent in the automobile and the average speed of travel, to find that the average net speed of travel (distance covered divided by time spent in and supporting the automobile) is barely faster than walking speed. But with our lives designed around the automobile, it is often "too far to walk."

When considering needs and energy, then, it becomes important to ask, as Hazel Henderson does, "Do Americans use energy slaves, or have they themselves become energy slaves?"[32]

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[29] See, for example, Allen Johnson, "In Search of the Affluent Society," Human Nature, (September 1978), pp. 50-59.

[30] Johnson, "Affluent Society," p. 53.

[31] Ivan Illich, "Net Transfer of Lifetime," in Energy and Equity (New York: Harper and Row, 1974), p. 30.

[32] Hazel Henderson, "System, Economics, and Female," CoEvolution Quarterly (Summer 1974).

D. HOLISTIC LIFESTYLE ASSESSMENT

Holistic Lifestyle Assessment is a relatively new and evolving toolbox, containing a variety of means for developing decision-making processes that more completely reflect costs and benefits to the entire system than do such relatively narrow measures as those of conventional economics. The purpose of HLA is to:

- identify the inputs, throughputs, and outputs of a human system in real energy terms;
- delineate the human needs that require energy expenditure;
- recognize the impact of aggregate lifestyle components on the physical and cultural environment; and
- provide a basis for comparative evaluation of goods and activities.

The combined needs of different individual lifestyles have varying impacts upon both the surrounding natural environment and the cultural environment.

The impact of aggregate lifestyles upon our energy resources may 1) be within the limits of tolerance of the environment; or 2) exceed the limits of tolerance of the environment. In the latter case, additional energies will be required to return the environment to its previous configuration. The additional energies can be provided by the individual or by society.

In this attempt to create tools that are both more accurate than strictly economic measures, and that are in particular more sensitive to social and/or environmental costs, people have devised both analytical and synthetic approaches. Each approach, in its own way, attempts to make explicit to the decision-maker--whether an individual consumer or a government agency--the impacts of actions on the whole system, including the components that are not readily revealed. In some cases, the mechanism of that integration is apparent (as with energetic analysis), while in other cases (such as energy tags on appliances), the final rating is key and the process for achieving it is left behind the scenes. The following list presents a variety of parameters for Holistic Assessment:

- consumption
- happiness
- community standards
- checklists and cookbooks
- Net National Welfare (NNW) and Measure of Economic Welfare (MEW)
- Environmental Impact Assessment (EIA)
- Social Impact Assessment (SIA)
- Energy Input/Output Analysis (I/O)
- energetics
- energy tags
- Quality of Life (QOL)
- Wellness Inventory
- Voluntary Simplicity (VS)
- simple living

We shall consider five of these assessment parameters--Quality of Life, Environmental Impact Assessment, Wellness Inventory, Energy Tags, and Energetics--in greater detail.

1. Quality of Life

Quality of Life, in common usage, is intangible, something people feel as much as they know. It is a reflection, perhaps, of why people choose to live in one place rather than another. Many researchers over recent decades have tried to make those feelings explicit, by identifying "quality of life indicators"--the variables that have the most significant impact on what people perceive as quality of life.[33,34,35] The particular spectrum of indicators varies widely, but a representative list might include:

- urban energy efficiency
- state of the natural environment
- access to amenities
- access to public services
- level of public health
- citizen influence and community control
- economic opportunity
- livability of climate

In addition to the difficulty of determining which indicators are more "key" than others, many of these indicators are difficult to quantify. Yet, quantification is necessary for correlating the various indicators in order to come up with comparative measures of qualify of life for different places.

2. Environmental Impact Assessment

Environmental Impact Assessment is a holistic assessment tool that has been mandated by law for all activities of federal agencies or utilizing federal funds that have significant environmental effects (National Environmental Policy Act, NEPA, 1969), and

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[33] Ben-Cheih Liu, Quality of Life Indicators in US Metropolitan Areas, 1970: a Comprehensive Assessment (Washington, D.C.: Environmental Protection Agency, 1975).

[34] Michael J. Flax, A Study in Comparative Urban Indicators: Conditions in 18 Large Metropolitan Areas (Washington, D.C.: Urban Institute, 1972).

[35] Duane Elgin, City Size and the Quality of Life (Stanford CA: Stanford Research Institute, November 1974).

for specified classes of projects at the state level (California Environmental Quality Act, CEQA.[36,37])

Unlike Quality of Life studies, the EIA process does not attempt to come up with a single integrated measure of comparison. Rather than trying to condense the implications of an action into a computed rating, the EIA process attempts to identify and trace all relevant impacts of proposed actions, and presents all of them. Integration, and consideration of the relative significance of the various factors, is the task of the regulatory, judicial, or political process.

An important feature of the EIA approach is that the legislation requires the assessors to consider also the impact of (1) alternative paths to achieving the goals of the project under study; and (2) not doing the project at all.

The EIA process has served as a powerful tool for anticipatory planning, enabling government agencies as well as concerned citizens to consider environmental implications of projects before they are undertaken, and to make more informed choices. The approach is not without problems. While avoiding the loss of information that is the inevitable result of the "reducing valve" nature of the QOL ratings, EIA often goes to the other extreme, producing studies of such detail and complexity that they are out of reach of all but the most dedicated.

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[36] Thomas G. Dickert and Katherine R. Domeny, Environmental Impact Assessment: Guidelines and Commentary (University Extension, UCB, 1974).

[37] M. Blissett, Environmental Impact Assessment (Engineering Foundation, 1976).

An interesting offshoot of the EIA is the Social Impact Assessment (SIA), inspired partially by the power and usefulness of the EIA, and partially by criticism of the EIA for focusing solely on the "natural" environment, to the exclusion of more directly human concerns.[38] A hybrid, in a way, of the EIA and QOL approaches, "SIA estimates and appraises the condition of society as it is organized and changed by the large-scale application of high technology...considering what is:

(a) technologically practical;
(b) environmentally appropriate;
(c) socially acceptable;
(d) economically viable;
(e) legally sound;
(f) politically feasible;"[39]

A component of SIA that has been used readily because of its more limited scope is the Employment Impact Statement,[40] which attempts to assess direct and indirect job creation and loss resulting from a proposed project. (See Figure 1.) Like the Environmental Impact Statement, the Employment Impact Statement considers the impact of alternative approaches to meeting the same need, and considers quality and permanence of employment impacts, as well as their size.

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[38] James McEvoy III and Thomas Dietz, Handbook for Environmental Planning: The Social Consequences of Environmental Change (New York: Wiley, 1977).

[39] Desmond M. Connor, "Social Impact Assessment: The State of the Art," paper presented to Ontario Association for Environmental Management, Toronto, March 6, 1977.

[40] Avrom Bendavid-Val, Employment Impact Statement (Portland: RAIN, 1977).

EMPLOYMENT IMPACT STATEMENT

JOBS CREATED

1. How many new local jobs will be *directly* associated with the proposed new facility (program, project, etc.)?

2. How many new local jobs will be created indirectly by local purchases of supplies and services by the new facility?
(This can be roughly calculated by: (a) obtaining estimates of the new facility's annual local purchases of supplies. (b) figuring the proportion that will go to pay the wages of new workers that local suppliers will have to hire to handle the increased business: (c) and then dividing by local average wage, to convert the dollar figure to a jobs equivalent. Consistent and reasonable "guesstimates" are OK.)

3. How many *induced* local jobs will the new facility generate?
(This can be roughly calculated by: (a) estimating the percentage of new direct and indirect payrolls that will ultimately become local personal expenditures by workers; (b) figuring the proportion that will go for wages of new workers that local retailers will have to hire to handle the increased business; (c) and dividing by the average local wage to convert the dollars to job estimates.)

4. Total number of jobs created:
(direct + indirect + induced = total)

5. How many jobs will the new facility eliminate—directly or indirectly—in other local businesses?

6. NET number of jobs created:
(number of jobs creat-d minus number of jobs eliminated)

Proposed Project	Alternative Processes	Alternative Investment

ALTERNATIVES

1. What are the employment impacts of alternative means of providing the same services?
(These alternatives can be different production processes—such as employing bank tellers instead of computers to process checks—or different institutional arrangements. Small, locally-owned shops keep business profits within a community, where they provide indirect and induced jobs, while large, outside-owned franchises remove profits—and induced jobs—from the community and frequently purchase supplies from outside suppliers they own, reducing indirect jobs in a community.)

2. What are the employment impacts of alternative uses of the same investment resources? (particularly if public funds)
Almost any expenditure of money creates jobs, but using that money for different purposes may have very different results while providing the same amount of jobs. Building new power plants provides jobs and insulating homes provides jobs, but only the latter eliminates need for unnecessary future expenditures of work, dollars and energy. Expenditure of tax money provides jobs but raises our taxes, giving us each less to spend, which would have provided jobs anyhow. And expenditures for different purposes provides very different numbers of jobs and use of resources. Hospital services provide three times as many jobs per dollar spent as highway construction. Expenditure of funds for waste treatment construction, social security benefits or national health insurance instead of present Army Corps of Engineers projects would provide 30 to almost 60% increases in employment.

COMMUNITY IMPACTS

1. What special conditions will be required to sustain the activity being planned? (Do the product produced and the proposed rate of resource use indicate sustainable operation? Are special markets, government subsidies, local resources, abnormally low local wages necessary?)

2. Are the activity and the jobs it creates seasonal or cyclical over a longer period of time?

3. How many of the new jobs created will be permanent?

4. How many of the new jobs will be temporary? (e.g., associated only with construction or initial operation)

5. What will happen to workers in temporary jobs when their work ends?

6. What will be the distribution of new jobs among types and wage levels?

Type of job	Wage	Number	Percent of Total

7. Will the income distribution of the jobs provided increase inequality of wealth in the community?

8. How many of the new jobs are likely to be filled by local unemployed people?

9. How many of the new jobs are likely to be filled by workers whose employment has been terminated, directly or indirectly, because of the new facility?

10. How many of the new jobs are likely to be filled by local residents? How many by newcomers?

11. How many of the new jobs are likely to be filled by men? women? minorities?

12. Will the new facility make it harder for people without special education or training to get jobs in the community?

13. Will the new facility make local employment more dependent on outside decisions that don't incorporate the needs of the community?

14. Will the financial base of the new project make it comparatively harder for small local industry to compete fairly for loans?

Prepared by RAIN Magazine from an earlier version by Avrom Bendavid-Val, Center for Growth Alternatives.

Figure 1. A COMPONENT OF SOCIAL IMPACT ASSESSMENT

3. Wellness Inventory

The Wellness Inventory is a personally-focused component of HLA. It assesses primarily the health and well-being of the individual, but it is recognized that the health of the larger system is one of the contributors to the status of the individual. The Wellness Inventory is an anticipatory and comprehensive approach that focuses on health rather than disease, and prevention rather than cure.

Dr. John Travis, developer of California's Wellness Resource Center, defines wellness as "more than the absence of illness...an ever-expanding experience of purposeful, enjoyable living...a life-style you design in order to achieve your highest potential for well-being."[41] While different practitioners offer a slightly varying mix of detailed components, there are basic threads that link them all. Donald B. Ardell, in High Level Wellness,[42] lists these as:

- self-responsibility;
- nutritional awareness;
- stress management;
- physical fitness;
- environmental sensitivity.

Travis' Wellness Inventory allows a person to evaluate and monitor a wide range of personal states and behaviors, and to develop strategies to change them, individually or in consultation with a professional team.

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[41] John W. Travis, Wellness Workbook: A Guide to Attaining High Level Wellness (Mill Valley, CA: Wellness Resource Center, 1977).

[42] Donald B. Ardell, High Level Wellness: An Alternative to Doctors, Drugs, and Disease (Emmaus, PA: Rodale Press, 1977).

The parallels of the Wellness Inventory with more ecologically-oriented HLAs lies not only in its comprehensive and planned approach to personal health, but also in the fact that many of the recommended strategies developed in response to the Inventory are in harmony with behavior necessary for maintaining a resource-conserving or voluntary simplicity lifestyle.

4. Energy Efficiency and Energy Tags

While the previous examples focus primarily on the societal scale (with applications for individuals), this example represents an individual-focused tool that attempts to bring some larger system concerns into consumer decisions. The final example has relevance at both levels.

Two approaches have been proposed to enable a consumer to integrate energy concerns with economics in purchasing appliances, by providing condensed energy information attached to the product in the showroom. The first proposal, specially suited to units such as air conditioners, is the Energy Efficiency Rating (EER)[43] which, in effect, compares the amount of electricity required for an air conditioner to deliver a given amount of "coolth," thus allowing the consumer to consider operating costs, as well as initial costs, in deciding which unit to purchase. A variation of that approach, life-cycle costing, computes total costs to the consumer over the life of the appliance, including initial outlay, plus energy costs (determined in part by energy efficiency) over the anticipated lifetime of the unit.

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[43] David Morris and Gil Friend, Kilowatt Counter (Milaca, MN: Alternative Sources of Energy, 1975).

A more far-reaching notion, proposed by the Canadian "Selective Conserver Society" report, is the "energy tag," which would reveal the "embodied energy" costs of each product.[44] That is, the tag would present the total direct and indirect energy inputs used to produce the product, thus giving the consumer an idea of the comparative costs to society of producing each item.

5. Energetics

Energetic analysis, as developed by H.T. Odum and associates, is an attempt to apply a coherent, energy-based system of accounting to human activities.[45] The complete approach is discussed in detail in the section of this sourcebook entitled "Fundamental Concepts of Energy." In this section, we consider the key element of Net Energy Analysis, which has particular significance as a tool for Holistic Lifestyle Assessment.

Net Energy Analysis is based on the concept that it costs energy to produce energy, and that the socially significant quantity is not the gross energy produced, for example, by a coal mine, but is the net energy available for end uses after deducting the energy expended extracting, processing, transporting, and converting the original resource. Just as one would make a business investment decision by comparing the net profit of two enterprises, Net Energy Analysis can be used to evaluate the actual return to society of different energy sources being considered for investment.

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[44] Kimon Valaskakis, Peter S. Lindell, J. Graham Smith, eds. The Selective Consumer Society, vol. 1 (Montreal: GAMMA, 1978).

[45] H.T. Odum and E.C. Odum, The Energy Basis for Man and Nature (New York: McGraw Hill, 1976).

As energy resources become more expensive in both economic and energetic terms, concern with net yield will become a more significant factor in allocating capital and energy resources to energy development. Although Net Energy Analysis, and Energetic Analysis in general, are tools that are too complex to be used in individual lifestyle decisions, it is important for people to understand these concepts in order to make informed decisions about energy policy.

E. IMPLICATIONS: HEALTHY HUMAN ENVIRONMENTS

The various approaches to Holistic Lifestyle Assessment described on the previous pages are attempts at identifying healthy environments for human beings. The incomplete, short-range accounting methods of the past have contributed to a twentieth century society whose designs for working and living environments are very likely antipathetic to the health and psychological well-being of its own members. The vast super-complexity of our lives seems to be making new psychological and physiological demands on us that are ever-increasingly difficult to handle.

In order to cope with the tension that we face in our world, we need to understand the dynamics of stress: what stress is, what background and immediate circumstances elicit it, and how we respond to it. With a greater understanding of these processes, we can learn to encourage healthy adaptations to these ever-present elements in our environment.

We need to become consciously aware of the unconscious demands made upon us by the lifestyles we adopt. The environments we choose to live and work in do profoundly affect our health.

When people interact at home, in the classroom, at the office or the factory, in a city or in any social situation, they create a "climate" or "atmosphere" that has a distinct personality. Just as each person has a unique personality, so does each environment. Some people are supportive; some environments are supportive. Some people are very imposing and controlling; some environments are also controlling.

The realtionship between the social environment and the individual has only recently become the subject of systematic research in several fields of study. The main currents of scientific thought in social ecology, psychiatry, medicine, and epidemiology emphasize the identification of adaptive and maladaptive (or dysfunctional) reactions and their relationship to changing elements of the environment.[46,47,48,49] Although much of the evidence gathered so far in these fields is tentative and hypothetical, a great deal can be affirmatively stated on the basis of the growing body of knowledge in environmental biology.

1. Responding to Environmental Stimuli

Our environment, that which exists in the world outside our physical bodies, is constantly providing us with vital inputs and is receiving our outputs. It is our interaction with the environment that keeps us alive.

We are dependent upon a constant exchange of water, heat, carbon dioxide, oxygen, food, vital minerals, organic substances, and information across the surface of our skin, the epithelial lining of our respiratory, gastrointestinal and urinary tracts, and our special sense organs.

In the acquisition of information, the sense organs play the major role. These include the eyes, the ears, the olfactory organs,

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[46] P.M. Insel and R.H. Moos, Health and the Social Environment (Lexington, MA: Heath, 1974).

[47] R.S. Lazarus, "Psychological Stress and Coping in Adaptation and Illness," International Journal of Psychiatry in Medicine, 5:4 (1974), pp. 321-333.

[48] L.E. Hinkle, "The Concept of Stress in the Biological and Social Sciences," International Journal of Psychiatry in Medicine, 5:4 (1974), pp. 335-357.

[49] L.E. Hinkle and W.C. Loring, eds. The Effect of the Man-Made Environment on Health and Behavior (Washington, D.C.: Center for Disease Control, DHEW, 1977).

the taste organs, and the special organs within the skin and inside the body that are sensitive to touch, temperature, pressure, spatial orientation and acceleration, etc. The sense organs are closely associated with the central nervous and neuroendocrine systems and, as such, are capable of influencing virtually all bodily processes.

It is possible, then, for the human organism to use the information acquired by the sense organs to organize adaptive responses that involve the entire human system. In addition, this information can be used to draw inferences about those aspects of the environment that do not impinge directly upon the organism, but are removed in time and space. This occurs as the information is passed through the higher brain centers.

It is the awareness of this "environment at a distance"--an environment composed of human interaction and social interchange, that makes the human animal so uniquely adaptable and at the same time so vulnerable to psychosocial overload.

We are all subject to a hail storm of data being hurled at our senses, demanding to be received, processed, and acted upon. We take in a great deal of external data and try to fit these new bits of information into our conceptual schemes, so that we can make sense of them. One can experience information overload when more stimuli are received than can be processed. Then new data must be shut out or accepted in a low-information, disordered state. It is this state of psychological disorder that Toffler (1970) terms "future shock," the result of the constant bombardment of our senses with stimuli that are so new and strange that we are left bewildered and disoriented in their wake.

2. The Stress Response

The available evidence indicates that responses to information acquired by the sense organs and processed by the central nervous system can have a profound effect on the vital processes of human beings.

The physiological effects of neuroregulatory mechanisms evoked in response to social stimuli have been studied in considerable detail by physiologists and endocrinologists during the past century. Two notable workers in this field are Walter B. Cannon, who dealt primarily with the immediate responses of the organism to such stimuli, and Hans Selye, whose "General Adaptation Syndrome" describes the long-term adjustments necessitated by prolonged stress and the more immediate "emergency response."[50,51,52]

The emergency reaction, as Cannon describes it, involves the sympathetic nervous system acting in conjunction with the hormones secreted by the adrenal medulla--adrenaline and noradrenaline. The emergency reaction serves to mobilize the body's resources for the swift act of "fight or flight." When we recognize a danger, our brain sends a signal to the adrenal medulla, causing the release of adrenaline and noradrenaline directly into the bloodstream. From

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[50] Walter B. Cannon, *The Wisdom of the Body* (New York: W.W. Norton, 1932).

[51] Hans Selye, *The Physiology and Pathology of Exposure to Stress* (Montreal: AETA, 1950).

[52] Hans Selye, *The Stress of Life* (New York: McGraw Hill, 1956).

the bloodstream, these hormones are distributed throughout the body. The blood flow shifts from so-called noncombat organs (the stomach and intestines) to combat organs (the brain, heart, and muscles), and the concentration of sugar and oxygen in the blood is increased. An increased rate of deep breathing forces more oxygen into the bloodstream, and the spleen releases its reserve of red cells for greater oxygen-carrying capacity. The increased heart rate causes blood pressure to rise, which in turn facilitates the movement of red cells in and out of the capillaries in the lungs.

Adrenaline stimulates the liver to transform sugar from storage form (glycogen) into burnable form (glucose), which is then poured into the bloodstream. Adrenaline also triggers the formation of thrombin, a substance that (together with other substances) causes the blood to clot. These chemical changes and the energy they produce increase body heat, which is moderated by a number of processes, including perspiration.

In humans, this response is an essential psychophysiological process that enables them to respond to a multitude of challenges each day. It is one of the body's most sensitive and vital survival systems. In the rapid pace of the modern world, however, it is often too late and in many cases inappropriate, as the social situation rarely allows either fight or flight.

When your boss tells you that you will not receive the raise that you were expecting, for instance, you can neither assault him or her nor run from the situation. You must internalize your distress and maintain an outward calm, regardless of your body's state of excitation. Significant biochemical changes have taken place as messages spread throughout your neuroendocrine system, but there may be no "socially acceptable" action to take. There is also the possibility that, although the external stimulus may have long since passed on, the psychological state may remain, prolonging the physiological stress response.

Upon the removal of the stressful situation, the body returns to its normal level of homeostasis and no harm is done. However, if the stressor is in evidence over a prolonged period of time, or if new stressors constantly replace the fading ones, the bodily reactions are never relaxed.

The body, constantly bombarded by stimuli that demand attention, is continually on a nervous alert. Its response to the stimuli is to maintain increased hormonal flow, with the resultant high blood pressure, heart rate, etc., of Cannon's emergency response. In other words, the body adapts to the continuous downpour of new stimuli by maintaining a state of alert, ready to combat the stress. It is under these circumstances, when the stress response is prolonged and unabated, that the biochemical changes associated with stress become potentially detrimental to health. Hans Selye calls the long-term stress response the General Adaptation Syndrome, which he divides into three stages:

- The alarm reaction, "...the body's defenses are mobilized to meet the assault." The stressing stimuli operate through sensory pathways to affect the hypothalamus, which brings the hormones of the pituitary (primarily ACTH) into play, stimulating the release of the hormones of the adrenal cortex.
- The stage of resistance. The organism attempts to resist the stressor by continued and increased levels of hormone release.

- The stage of exhaustion. The organism is no longer able to sustain the process of adjustment, and the animal succumbs.

Selye has demonstrated that the physiological reactions are the same in response to a wide variety of stressful conditions, including starvation, poisoning, infections, extreme cold, extreme heat, and surgical hemorrhage. In addition, he determined that people suffering from a variety of specific stress induced illnesses are likely to have certain general symptoms in common, such as headache, fever, fatigue, aching muscles and joints, loss of appetite, and general feelings of malaise.

The history of illness shows a progression in recent decades from acute, infectious disease to chronic ill health. The incidence of acute, contagious diseases has been greatly reduced by modern medicine; but at the same time, the stressors to which we are exposed have consistently increased, bringing with them widespread occurrences of heart disease and other illnesses. Environmentally-induced chronic illness has become the nation's major health problem.

3. What Triggers the Stress Response?

Undoubtedly, the pace and complexity of our advanced technological society is responsible for much of the stimulus overload from which we suffer. Recognizing those general environmental and social stressors that require an adaptive response is an important first step in detecting the degree of stress to which we are all subjected. Each person responds differently to stressful situations, due to the overall circumstances and his or her individual physical and emotional makeup. Thus, many stressing stimuli are culture and indidual specific. It is probable, however, that there are some very general factors in the environment that affect us all to some degree.

Thomas H. Holmes and Richard H. Rahe, of the University of Washington School of Medicine, conducted a study that provided outstanding contributions to the identification of events that can trigger a high degree of personal stress, ultimately resulting in the development of some type of psychosomatic illness.[53] With over 5,000 patients, Holmes and Rahe developed a systematic method of correlating life events with susceptibility to illness (See Figure 2.) Although their research indicates that there are some very specific qualitative stimuli that result in a high probability of illness, it should be stated that in order to produce illness, these stimuli most likely must be perceived as being stressful. In other words, in order to be an "adequate stimulus" to elicit the stress response, it must appraised as being a significant input.[54]

Long ago, the sight or sound of a large beast evoked the fight-or-flight response, a heightening of activity in those bodily systems that interact directly with the outer world. Today, such an image (as of an automobile) is disregarded. The automobile is not normally perceived as a stressful object. We have learned to disregard a great deal of data that would have been very significant

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[53] T.H. Holmes and R.H. Rahe, "The Social Readjustment Rating Scale," Journal of Psychosomatic Research, vol. 11 (1967), pp. 213-218,

[54] For further discussion on the importance of "cognitive appraisal" to the concept of stress and illness, see: R.S. Lazarus, "Stress and Coping in Adaptation and Illness," International Journal of Psychiatry in Medicine, 5:4 (1974), p. 322; and L.E. Hinkle, "The Concept of Stress," International Journal of Psychiatry in Medicine, 5:4 (1974), p. 347.

LIFE EVENTS AND SUSCEPTIBILITY TO ILLNESS

Holmes and Rahe (1967) suggest that events leading to significant change, pleasant or unpleasant, can lower an individual's resistance to disease. They studied several populations and found a significant relationship between the magnitude of life changes and the time of disease onset. In addition they found a strong positive correlation between magnitude of life change and the seriousness of the illness experience.

They constructed the Social Readjustment Rating Scale (SRRS) which consists of life event items weighted according to the adaptive requirement of the life event. Eighty per cent of the people exceeding a SRRS score of 300 in one year, for example, became depressed, had heart attacks or developed other serious illnesses

LIFE EVENTS AND WEIGHTED VALUES

1.	Death of spouse	100
2.	Divorce	73
3.	Marital separation	65
4.	Jail term	63
5.	Death of close family member	63
6.	Personal injury or illness	53
7.	Marriage	50
8.	Fired at work	47
9.	Marital reconciliation	45
10.	Retirement	45
11.	Change in health of family	44
12.	Pregnancy	40
13.	Sex difficulties	39
14.	Gain of new family member	39
15.	Change in financial state	38
16.	Death of close friend	37
17.	Change of work	36
18.	Change in number of arguments with spouse	35
19.	Mortgage over $10,000	31
20.	Foreclosure of mortgage	30
21.	Change of responsibility at work	29
22.	Son or daughter leaving home	29
23.	Trouble with in-laws	29
24.	Outstanding personal achievement	28
25.	Wife beginning or stopping work	26
26.	Beginning or ending school	26
27.	Revision of habits	24
28.	Trouble with boss	23
29.	Change in work hours	20
30.	Change in residence	20
31.	Change in schools	20
32.	Change in recreation	19
33.	Change in social activity	18
34.	Mortgage less than $10,000	17
35.	Change in sleeping habits	16
36.	Change in number of family get-togethers	15
37.	Change in eating habits	15
38.	Vacation	13
39.	Minor violations of law	11

SOURCE: T.H. Holmes, and R.H. Rahe, "The Social Readjustment Rating Scale," Journal of Psychosomatic Research, vol. 11, 1967, p. 213.

Figure 2. SOCIAL READJUSTMENT RATING SCALE (SRRS)

in another time and place. Thus, the simplest answer to the question of what precipitates stress is that stress is produced by whatever the individual sees as a significant environmental change.

It is also important to remember that the stimulus need not be involved with a real encounter. For instance, it is not necessary for encounters to be direct physical contacts in which the person is wounded or scared. The fear or recollection of physical harm can very likely induce a reaction similar to that evoked by a direct physical encounter. When mediated through the higher brain centers, any number of sensory inputs may construct mental images that are equally capable of triggering the stress response. Thus, an adequate stimulus for the stress response is, like beauty, in the eyes of the beholder; but the presence of stress is highly correlated with significant environmental changes, and these changes are ever-increasing in our complex and highly mobile society.

We live in a unique period of history. Until this century, it might have been said that most people's lives were essentially like that of their grandparents; today, a "generation gap" seems to exist, even between brothers and sisters of a few years' difference in age. Change, propelled by technological development, exerts a pervasive influence in modern society, and modern technological changes are occurring on a scale wholly unknown to our ancestors.

> ...In the last century, we have increased our speeds of communication by a factor of 10^7; our speeds of data handling by 10^6; our energy resources by 10^3; our power of weapons by 10^6; our ability to control diseases by something like 10^2; and our rate of population growth to 10^3 times what it was a few thousand years ago.[55]

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[55] John Platt, "What We Must Do." Science (November 28, 1969), p. 115.

4. Alienation

Alienation is the direct outcome of information overload and has been cited as an underlying cause of many internal conflicts related to physical and mental illness.

> The ultimate adaptation to an overloaded social environment is to totally disregard the needs, interests, and demands of those whom one does not define as relevant to the satisfaction of personal needs, and to develop highly efficient perceptual means of determining whether an individual falls into the category of friend or stranger. The disparity in the treatment of friends and strangers ought to be greater in cities than in towns; the time allotment and willingness to become involved with those who have no personal claim on one's time is likely to be less in cities than in towns.[56]

Alienation is an illness in which there are five cognitive states: 1) powerlessness, a perceived inability to affect one's future; 2) meaninglessness, the feeling that life is pointless; 3) normlessness, a sense of the inefficacy of social norms in achieving individual goals; 4) isolation, the feeling that one's own values are not shared by anyone else; and 5) self-estrangement, the idea that one has not lived up to his or her own standards.[57]

Historical trends that have been postulated to be producers of alienation are as follows: 1) increased largeness: cities and corporations have grown beyond our ability to simply understand their problems and to solve them; 2) a decrease in personal identity with family, relatives, and acquaintances which is largely due to 3) increased geographical and social mobility; 4) increased social differentiation due to specialization; and 5) the decline of traditional social norms in the face of rising secularized, rationalized norms. Such trends have produced loneliness and estrangement in the people of our society (Elgin, 1974).

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[56] S. Milgram, "The Experience of Living in Cities," Science, vol. 157 (1972), p. 1462.

[57] M. Seeman, "On the Meaning of Alienation," American Sociological Review, vol. 24 (1959), pp. 783-791.

The adjustments we make in an attempt to cope with our stressful society are often very dangerous in themselves. Alienation can render us less effective and more miserable than we were before. Our general biological adaptation response to environmental stressors, which can result in tissue damage and can even lead to any number of chronic diseases, is certainly not healthy. How can we avoid these terrible psychological and physiological responses to the world we are creating?

Numerous answers to this question have been considered and are being employed. One strategy is to use our technology to alter our physical make-up. The use of drugs is an example of this strategy; a variety of pharmaceuticals provide physiological and psychophysiological tranquility and, of course, alcohol use is the most flagrant form of drug abuse in our society today. But, beyond pharmacopeia, our technology is also being used to construct and implant artificial organs. It has been suggested that mechanical organs, or prostheses, may operate without subjection to psychological stressors. There are problems with this technological strategy, however. Does the prolonged use of drugs produce sickness in another portion of the total person? Can the modification of our biological selves with machinery alleviate the problems of our psychological selves?

A simple coping strategy is to resume the activity for which we are biologically built. Until recent times, people have been physically active. In terms of all of human history, we have rather suddenly developed a sedentary society to which we, as evolving organisms, are unaccustomed. Since we are not accustomed to prolonged inactivity, our bodies are not now operating at peak efficiency. We all need to reintroduce exercise into our lives.

Many people who do exercise in our society have found jogging, bicycling, swimming, etc., to be psychologically as well as physiologically healthy. A recent study by Dr. Ralph Paffenbarger, Jr. of some 17,000 Harvard alumni supports their faith in exercise. Over a six- to ten-year period, the subjects who exercised less than three hours and burned less than 2000 calories per week had a 64% higher risk of heart attack than their exercising schoolmates. Moreover, this resistance to heart attack was independent of blood pressure, smoking habits, family health history, or the earlier physical fitness of the subjects. The suggestion of the study is that good, hard, strenuous activity involving at least three hours per week may be a significant factor in preventing many stress related diseases.

5. The Relaxation Response

Other successful stress reduction techniques involve the so-called "relaxation response." The relaxation response is a generic term that refers to an innate, integrated set of physiological changes that can potentially counteract the harmful physiological effects of the stress response.[58] It results in an altered physiological state characterized in part by decreases in respiratory and heart rates, muscle tension, the concentration of blood lactates, and blood pressures. These characteristics mark a general reduction in the metabolic rate, in both aerobic--as measured by respiration--and anaerobic--as measured by blood lactate--processes. Evidence indicates that regular elicitation of the relaxation response results in the maintenance of a lowered blood pressure. These pervasive slowdowns stand in direct opposition to the stress of the general adaptation syndrom. The body is permitted to relax deeply, more deeply than in sleep, while it undergoes the restorative processes that counteract those reactions triggered by increased adrenaline and noradrenaline flow. Thus, eliciting the relaxation response appears to be an effective method of counterbalancing our body's natural tendency toward arousal and defense.

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[58] H. Benson, J.F. Beary, and M.P. Carol, "The Relaxation Response," Psychiatry, vol. 34 (1974), pp. 37-46.

How is this hypometabolic state achieved? Dr. Herbert Benson suggests that many routes can be taken to achieve the relaxation response. He has compared several methods for inducing the response. (See Figure 3.) Hypnosis results in the physiological state

Technique	**Physiologic measurement**					
	Oxygen consumption	**Respiratory rate**	**Heart rate**	**Alpha waves**	**Blood pressure**	**Muscle tension**
Transcendental meditation	Decreases	Decreases	Decreases	Increases	Decreases	Not measured
Zen and Yoga	Decreases	Decreases	Decreases	Increases	No change	Not measured
Autogenic training	Not measured	Decreases	Decreases	Increases	Inconclusive results	Decreases
Progressive relaxation	Not measured	Not measured	Not measured	Not measured	Inconclusive results	Decreases
Hypnosis with suggested deep relaxation	Decreases	Decreases	Decreases	Not measured	Inconclusive results	Not measured

Figure 3. COMPARISON OF METHODS FOR INDUCING THE RELAXATION RESPONSE [Benson, 1974]

suggested by the hypnotist. Autogenic training, or biofeedback, is a learned, conscious control of normally involuntary processes. Most of these methods are effective, but probably the most popular techniques of eliciting the relaxation response involve some form of meditation or contemplation.[59]

Zen and Yoga in the East have long been recognized for their meditative techniques, and that model has now become popular in the West as Transcendental Meditation.[60] The West itself has a history of contemplation going back at least to the second century B.C. with Jewish Merkabalism, joined in later years by Christian mysticism. Clearly, one result of some forms of prayer is the elicitation of the relaxation response.

Dr. Benson notes four elements that seem common to the different meditative techniques: (1) a quiet environment that minimizes distractions; (2) a mental device, typically the repetition of a single-syllable sound or word; (3) a passive attitude that includes both mental and physical relaxation; and (4) a comfortable position. So located, the person repeats his or her word or sound at a comfortable pace, possibly in rhythm with breathing. This process, maintained for about fifteen to twenty minutes, will induce the relaxation response; and if practiced twice a day, the physiological changes may become persistent. Most people are able to achieve the response fairly readily, although eating before meditation can inhibit success, as can simply trying too hard to be relaxed. The response flows naturally by diverting one's normal mental activity through a particular device, to a more settled and restful state of mind and body.

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[59] Many stress management programs may use a combination of techniques and/or a combination of exercise, changed eating habits, and a form of relaxation.

[60] See, for example, K. Wallace and H. Benson, "The Physiology of Meditation," Scientific American (February 1972).

Exercise and the meditative elicitation of the relaxation response are very useful methods of coping with a high level of stressing demands. They do not work by reducing the number of stressors in the external environment, but through modifying the body's long-term detrimental response to those stressors. For this reason, exercise and the relaxation response are not final solutions to the problem of stress. Our successful adaptation merely allows us to temporarily adjust and maintain the incessant buildup of potentially adverse stimuli. Future shock continues to be a reality. Thus, coping itself can become part of a positive feedback cycle. Increased coping capacity can lead to increased stressful demands, which in turn necessitate still greater coping capacity. Ultimately, we will have to recognize for ourselves what Rene Dubos so insightfully tells us:

> Man should not try to conform to the environment created by social and technological innovations; he should instead design environments really adapted to his nature. He should not be satisfied with palliative measures treating the effects of objectionable conditions, but instead change the conditions. Now that scientific technology has made us so powerful and so destructive, we must try to imagine the kinds of surroundings and ways of life we desire, lest we end up with a jumble of technologies and countertechnologies that will eventually smother body and soul.[61]

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[61] R. Dubos, "Man overadapting," *Psychology Today* (February 1971).

6. Toward Voluntary Simplicity

Many Americans are already moving away from living and working environments that have grown beyond human scale, and are choosing an outwardly more simple and inwardly more rich life style. Researchers at Stanford Research Institute have begun to look at the growing movement toward what they have called Voluntary Simplicity.[62] They define Voluntary Simplicity (V.S.) as the process of intentional reduction in the complexity of our lives. It directly diminishes the number of stressors to which we are exposed through concerted efforts to lessen tensions and anxiety, encouragement of more rest and relaxation, reduced use of harmful chemicals, and the creation of greater inner harmony among members in a community. No longer faced with a plethora of low-information stimuli, but rather living in a simpler, more ordered world, we would avoid the chronic illnesses associated with hyperstress and be able to achieve a fuller development as human beings. Instead of moving toward alienation, we could grow into companionship.

The main thrust for V.S. has been carried recently by various counter culture movements, environmentalists, and futurists who recognize that our undifferentiated growth cannot be sustained on a global level. Now we see that V.S. is also beneficial on an individual level, as it reduces stress. Students of the human condition today are echoing Jesus, the Buddha, and more modern thinkers such as Thoreau and Gandhi in calling for material simplicity to promote personal growth. Such people argue, similar to Plato, that an excess of material things leaves one impoverished as well as entrapped by the objects themselves. Subordination to the material world leaves one captive by the importance of the objects--reducing or obfuscating the most important aspects of life. Proponents of V.S. argue not for blind abandonment of material wealth, but for the qualitative evolution of our inner selves, which can make us more full and happy. This evolution, this shifting of emphasis from material to immaterial growth, would result in a lessened demand for high technology. As the complexity of our physical environment decreases, the inversely related quality of our social environment would necessarily improve. Our lessened demand for large scale technology[63] would diminish the barrage of stressors, and the physiological and social damage that stress produces would be likewise diminished.

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[62] D.S. Elgin and A. Mitchell, "Voluntary Simplicity: Life-Style of the Future?" Futurist (August 1977).

The intention is to seek the level of material well-being that is most conducive to personal growth. Gross poverty disables a person, as one must usually satisfy physical needs before being able to satisfy psychological, social, and spiritual needs.

On the other hand, excessive material wealth (with its commitment of physical involvement) may very likely inhibit the development of the psychological, social, and spiritual qualities. A simple but sufficient lifestyle to be discovered between the extremes seems to be the most conducive to the development of the whole person.

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[63] The argument is not for the abandonment of technology altogether, but for a shift from large-scale, centralized, resource-intensive "hard" technologies to the decentralized "soft" technologies of a human scale. See Lovins (1977) and Schumacher (1973).

In summary then, it seems that our present lifestyle continuously demands the processing of such increasing amounts of data that, unable to stand the shock of massive, complex change, our bodies respond by becoming sick, and our minds respond by closing out further data. We develop chronic illnesses and reflect chronic alienation. Still, we can avert these symptoms by successfully coping with, as well as modifying our environment. Exercise and the relaxation response help us to retain our health by mitigating the effects of stress, providing at least a short-term reduction of the problem. The efficacy of drugs and prostheses in combating the dehumanizing effects of stress may be undermined by their own dehumanizing qualities. The ultimate healthy adaptation to stress is not to alter our bodies, but to alter our world. Instead of racing ahead of ourselves with increasing fragmentation, specialization, efficiency-driven mass production, etc., we might lead an enriched simpler life. A re-examination of values would enable us to enjoy what is about us and within us; and thereby our total health as people and as a world could grow.

F. IMPLEMENTATION

Implementation of Holistic Lifestyle Assessment as a tool, and realization of its goals, may happen at the level of cultural and value change, the market, and the regulatory process. It is possible to argue for the primacy of one level or another, but probably more useful to recognize that changes will go on at all levels, and that changes on one level will affect the others. Each is necessary; none is sufficient on its own.

As we have stated previously, external and internalized value systems are so important in the determination of lifestyle, of what one "needs," what people will sacrifice for and what they will do without, that the importance of value change for enduring changes in societal behavior is undeniable. The failure of Prohibition in the 1920s as an imposed policy underscores that importance. Value change is not an unusual process. It goes on all the time, has gone on throughout history, though perhaps more slowly than in recent years. But it has rarely been a directed process; rather it has been a cumulative response to changing conditions.

> Man is not pushed by a unified system mechanistically into intolerable conditions but assesses the circumstances around him and responds actively by adapting his goals and values ...Such adaptations occur as a persistent process when the strains of life are experienced. Man's fate is shaped not only by what happens to him but also by what he does, and he acts not just when faced with catastrophe but daily and continuously.[64]

The current situation is different, in that it is a directed process, in two ways. First, many present trends--e.g., the commodity consumption economy and lifestyle, exponential growth in resource and energy use, and consolidation of economic power--have been since World War II, directly linked with the coherent (whether or not willful or conscious) promotion of a particular set of values through advertising and mass media.

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[64] Marie Jahoda, Models of Doom (1973), p. 211, cited in Bennett, The Ecological Transition, p. 155.

> Suddenly in 1946, government and industry started making identical pronouncements about regearing American life to consume commodities at a level never before contemplated. ...Thus, a new vision was born that equated the good life with consumer goods. An accelerated economy, the continuing expansion of wartime, added to a new consumer ideology achieved the greatest economic growth rate in this country's history from 1946 to 1970...Since economic growth and a consumer economy had to be based on selling far more commodities than were needed to meet actual needs, economic growth depended on advertising.[65]

Second, any process of change of values in response to HLA is itself a directed process, a change in values with a particular end or ends in mind--a resource-conserving lifestyle, environmental sensitivity, voluntary simplicity, a cooperative community. Thus it is a process that is in some way to be ushered. But our experience in guiding such processes is limited. It is not a simple matter, beyond even the basic difficult question of how values are to be transmitted and moved into the mainstream.

> Any social reformer who begins with the premise that society's ills derive from imperfections in the value system is faced with the serious ethical question of how much persuasion ought to be employed to change it. When does persuasion become coercion? Are they quantitatively or qualitatively different? A value system is constantly evolving, shifting, altering its preoccupations by inputs in the form of opinion, information, argument, and "persuasion."[66]

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[65] Jerry Mander, Four Arguments, p. 136.

[66] I. Martin, "Consumerist and Conservationist Values in Historical Perspective," p. 173, in Valaskakis, et al., The Selective Consumer Society.

1. Markets

Market changes to incorporate the principles of HLA are not fully separate from regulatory strategies. The market system, left to itself, has consistently tended to avoid consideration of externalities, to narrow the scope of information included in "price" to that most significant to the individual actors in a transaction in their atomized roles as producer and consumer (even though both are also citizen).

> The market system does not of itself include consideration for severe inequities in distribution, just as it does not consider either the welfare of future generations or the present costs to society and the environment.[67]

Under such universal circumstances, it would be against the interests of an individual firm to raise the prices of its products to reflect whole system costs. Its products would suddenly become more expensive than those of other enterprises that continued to externalize costs where possible; people would not buy the more expensive product unless their own values had changed significantly and they could afford to pay the premium to honor those values. On the other hand, if internalization of whole system costs were mandated by the government, competitive advantage would swing to the firm that was able to reduce its environmental burden; such a firm would be able to sell at a lower price than its more polluting competitors, would win a larger share of the market, and thus would pressure other firms in the industry to follow suit.

A variety of mechanisms have been explored to accomplish this effect. A great deal of technical economic analysis in this direction has been conducted in the United States by researchers at Resources for the Future.[68] In Europe, "pollution charges" have been levied, as a sort of tax, on industries in several countries. This has led to some success in reducing air and water pollution levels.[69]

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[67] Willis Harman, "The Coming Transformation," Futurist, (February 1977), p. 6.

Relying on market mechanisms has great appeal, in no small part due to its apparent simplicity. Once established, it is a self-regulating system, or at least more so than government bureaucracies. But the approach is not without problems. First, market mechanisms will affect only market transactions. But, as Scott Burns comments,

> Most of our economic statistics do not exist to quantify our real economic product but to trace the growth of exchange, of the market economy. We are not interested so much in economic welfare as in the circulation of money...Much of our economic activity occurs without market choice.[70]

Burns is referring not only to taxes--clearly not a free market transaction--but also to the barter economy and the household economy, which together, he maintains, represent as much wealth as the total of personal income via the market economy.

Secondly, even a well-tuned market, if evaluated by the same GNP/economic indicator "more is better" approach, may not maximize social welfare. Under present GNP accounting, society is better off producing polluting products and then cleaning up the mess, than producing less polluting products in the first place. GNP is simply not designed to measure welfare, only transactions. For example, we tend to look at an extensive transportation system as an unalloyed good thing, providing service and producing "wealth." Yet,

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[68] Anthony C. Fisher and John V. Krutilla, "Valuing Long Range Ecological Consequences and Responsibilities," Resources for the Future reprint no. 117, October 1974, Washington, D.C.

[69] Organization for Economic Cooperation and Development, "Paying to Produce," Environment, 18:5 (June 1976).

[70] Scott Burns, Home, Inc. (Garden City, NY: Doubleday, 1975), p. 62

> [in] some cultures, transportation is viewed as a measure of dysfunction in the social and living arrangements [and labor] is viewed as an output of production, as in the Buddhist concept of work and "right livelihood" as the path to self-actualization and satisfaction.[71]

Thirdly, market mechanisms do not handle equity well. While energy charges will reduce energy use and pollution impact, if these charges are implemented alone they can result in regressive taxation of the poor. Lower-income families spend a larger percentage of their incomes on basic needs. Thus, a flat-rate increase in energy costs takes a larger bite out of such a family's income than out of a well-to-do family's. A well-off family, while representing a far greater energy impact on society than a poor family, can also far more easily adjust to energy taxes and the like without disruption in the provision of basic needs. For that reason, many of the proposals for steep energy taxes and pollution charges include provisions for flat-rate tax rebates to reduce those inequities.

Thus a number of regulatory responses may also be used, in conjunction with market mechanisms, or on their own, to transmit the preconceptions and findings of Holistic Lifestyle Assessment into the daily life of the nation. In addition to the few mentioned above--taxes and tax rebates (there are many more approaches)--are strategies that affect the market less directly. In the case of toxic discharges, standards may be set for allowable discharge levels, which eliminates the competetive disadvantage to the voluntarily cooperating firm mentioned above. Alternatively, certain processes may be banned altogether due to their net social costs, as many people are attempting to do with nuclear power plants. Another approach is to severely restrict certain processes, as with pesticide use. Some analysts have even suggested banning advertising of products deemed to be harmful to the environment,[72] or taxing "perishability,"[73] or at least requiring disclosure of impacts in the advertising (as, for example, with health warnings on cigarette packages).

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[71] Hazel Henderson, "System, Economics, and Female," CoEvolution Quarterly (Summer 1974), p. 62.

Critics of regulatory strategies comment on their unwieldiness, and the growth of government bureaucracies that are themselves difficult to regulate. Given the scale of the modern corporation, however, individual activities may have little impact on what is done unless amplified through organization of those individuals, whether through private consumer organizations or the public sector.

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[72] Valaskakis, et al., Conserver Society, p. 342.

[73] Valaskakis, et al., p. 339.

G. LIMITS

As important a tool as HLA can be, it is important to be aware of its limits, for it may not do everything it is intended to do, or it may not do it the right way. Like any tool, its most efficient use depends on the awareness of its user.

The first limit is reflexive--it does not deny the value of HLA, but rather requires that it be fully, not partially, applied. Bruce Hannon has studied the possible counter-intuitive impact of energy conservation strategies, however well-intentioned. Hannon observes that any energy conservation choice, from one mode of energy use to another, is likely to result in economic savings.

> ...what does the consumer do with the dollars he saves by his modal shift? He can spend it or save it. As we learned earlier, in either case, energy will be required to provide for this freed expenditure....Armed with certain information, the consumer can purposefully redirect his income so that he does save energy on balance. It should be clear, however, that he can never save more energy by redirecting certain portions of his income than he can by becoming that much poorer.[74]

Without that information, however, a consumer could easily spend the saved money on a more energy-intensive activity. Or the bank in which that consumer places the savings may in turn invest the money in more energy-intensive activities. The net result to society from an energy conservation decision could be increased energy use. However, using HLA techniques properly, that is, fully tracing the "pathways through such a system of infinite interdependencies,"[75] would make it possible to predict and avoid such an effect.

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[74] Bruce Hannon, Energy, Growth, and Altruism, pp. 12-13.

[75] Hazel Henderson, Redefining Economic Growth, p. 137.

The second limit is implicit in the first. If Hannon and others are correct in that energy conservation does require income reduction, we may expect significant social resistance, and possibly significant impact. If, on the one hand, "simple living"[76] must be accompanied by income reduction, this could result in economic slowdown at the expense of jobs of individuals who may not be ready to "live simply." If, on the other hand, conservation strategies can actually result in greater employment than energy use as usual,[77] the income from those thus employed will in turn generate greater energy demand. Income reduction without excessive economic decline, if in fact beneficial, may not be achievable without a high degree of social coordination, and the risks of coercion implied thereby.

The third limit is the ultimately political setting of all but the most personal HLA decisions. Most decisions will affect more than one person, and diverse sectors of society. It is unlikely that such diverse actors will come to a complex decision-making process with identical values, or even to total agreement on what the facts are. Where that is the case, finding the "correct" decision will not be a neat analytical process, but a much less precise one.

> If there is a set of conflicting objectives representing different value judgments and choices between a quantifiable objective, such as a new plastics factory, and non-quantifiable objectives, such as the local residents' preference for clean air, beaches, and water for fishing, then this choice can only

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[76] Michael Phillips, "SRI is Wrong about Voluntary Simplicity," CoEvolution Quarterly (Summer 1977), pp. 32-34.

[77] See, for example, Jobs From the Sun (Los Angeles: California Public Center, 1978); and Richard Grossman and Gail Danneker, Energy and Economics, (Washington, D.C.: Environmentalists for Full Employment, 1976).

> be resolved politically. Of course, the various costs and benefits of the widest possible choice of alternatives can be presented for consideration, but only the participatory political process can resolve the value conflicts.[78]

Holistic Lifestyle Assessment can only serve, but never replace, a well-informed and active citizenry.

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[78] Henderson, Redefining Economic Growth, p. 138.

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IDEAL ENVIRONMENTAL WORLDVIEWS

A. INTRODUCTION

> Imagine insects with a lifespan of two weeks, and then imagine further that they are trying to build up a science about the nature of time and history. Clearly, they cannot build a model on the basis of a few days in summer. So let us endow them with a language and a culture through which they can pass on their knowledge to future generations. Summer passes, then Autumn; finally it is Winter. The Winter insects are a whole new breed, and they perfect a new and revolutionary science on the basis of the "hard facts" of their perceptions of snow. As for the myths and legends of Summer: certainly the intelligent insects are not going to believe the superstitions of their primitive ancestors.[1]

Using the device of analogy, William Irwin Thompson offers us an imaginary framework from which to consider the impending plight of a "civilization" of insects within a dynamically shifting universe. From the "outside," we have the possibility of exploring the illusions of a race of insects that enjoys some considerable knowledge about a remarkably brief temporal-spacial landscape. Perhaps like the Eskimo cultures, they are able to identify 29 separate varieties of snow as well as adapt to remarkably difficult conditions.

Further, this empirical breed is most efficiently able to comprehend and exploit its present environment in an attempt to expand "living standards," as well as to adapt energy to its self-directed purpose.

Finally, the process of codification is complete as a scientific-technical elite possesses key formulas of energy production--the life-sustaining adaption to environmental determinants. Through elaborate patterns of socialization, knowledge of the latest scientific developments are given to mechanical scribes for incubation and instant retrieval for future generations. The cumulative insight and understanding about their universe is the Weltanschauung (Worldview), or guiding pulse of this modern culture.

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[1] William Irwin Thompson, Passages About Earth (San Francisco: Harper and Row, 1973), p. 119.

Thus far, we have spoken only about the civilization in terms of its hegomonic cultural apparatus. Its science, language, and immediate experience offer sound, testable/predictable information from which to pattern later growth and experience. What of the individual insects participating within this cultural experiment? Do they possess a specific role to play in this dramatic unfolding?

> The individual, then, dervives his (her) world view socially in very much the same way that he derives his (her) roles and his (her) identity. In other words, his (her) emotions and his (her) self-interpretation like his (her) actions are defined for him (her) by society, and so is his (her) cognitive approach to the universe that surrounds him (her). This fact Alfred Schuetz has caught in the phrase 'world-taken-for-granted'--the system of apparently self-evident and self-validating assumptions about the world that each society engenders in the course of its history. This socially determined world view is, at least in part, already given in the language (rigidly defined symbolic sets...) used by the society.[2]

Individuals within our unfolding imaginary society also pattern their behavior about a codified set of laws. This provides the "legitimate monopoly of violence" to the ruling members of society. "Society predefines for us that fundamental symbolic apparatus with which we grasp the world, order our experience and interpret our own existence."[3]

As we explored our Winter insects, we would probably also discover an all too forgotten mythical past, which once served as the guiding compass of the culture. Myth--according to Mircea Eliade--"narrates a sacred history; it relates an event that took place in primodial time, the fabled time of the 'beginnings.' In other words, myth tells how, through the deeds of Supernatural Beings, a reality came into existence, be it the whole of reality, the Cosmos, or only a fragment of reality--an island, a species of plant, a peculiar kind of human behavior, an institution."[4]

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[2] Peter L. Berger, Invitation to Sociology: A Humanistic Approach (Woodstock, NY: Overlook Press, 1973), p. 117.

[3] Ibid.

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Myth offers to the insects the possibility of explaining, of organizing, as well as ritually "controlling" the forces of the vast universe. Myth (philosophy, religion, magic) forms the integral substance that conquers chaos and delivers order into the world. "The experience of conversion to a meaning system (Weltanschauung) that is capable of ordering the scattered data of one's biography is liberating and profoundly satisfying. Perhaps this has its roots in a deep human (like) need for order, purpose and intelligibility."[5]

Furthermore, myths explain "all the primordial events in consequence of which man (woman) became what he (she) is today--mortal, sexed, organized in a society, obliged to work in order to live, and working in accordance with certain rules."[6]

In short, our insect culture lives and breathes by an unwritten code that owes its power to an untrammelled belief in and strict adherence to reality-regulating laws of "thou shalts" as well as "thou shalt nots."

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[4] Mircea Eliade, Myth and Reality, trans. by Willard R. Trask (Evanston: Harper Torchbooks, 1963), pp. 5 and 6.

[5] Berger, Sociology, p. 63.

[6] Eliade, Myth, p. 11.

One perception of a unified package of Weltanschauung of a particular society is not without ancient roots.

> From time immemorial, we have sought to take the measure of the inner man (woman) by using as a guage his (her) outer manner. And more, he (she) has operated on a bit of tribal knowledge (isomorphism) which enables him (her) to assume that any perceived similarity in form, structure, or spirit allows for a sharing experience. Thus, in primitive men (women) and young children there exists an early fear or distrust of things which are not familiar to themselves in form, structure or spirit. As the individual matures, the distrust shrinks (or becomes refined?) and is made to include a rejection of those humans who differ in speech, skin color, spiritual beliefs, etc. In its positive form, this isomorphic tendency is at the base of man's (woman's) ability to identify with others; it is the heart of empathy and the spirit of education, religion, law, and medicine; indeed, it is the foundation of all communal living.[7]

The Worldview of a particular group and culture includes a metaphysical projection of the "whys" of existence as well as the explicity detailed formula for continued success in the pursuit of "the good life." Isomorphism (identity, oneness with) links child to parents, parents to kinship structure, kinship structure to tribe, tribe to nation, and nation to universe.

Throughout this chain of social being, individuals always retain the possibility of re-evaluating their "given" positions in the world. Re-definition by individuals who dare to transform their Weltanschauungen must change their social relationships. As Peter Berger rightly points out, "only the madman or the rare case of genious can inhabit a world of meaning all by himself (herself). Most of us acquire our meanings from other men (people) and require their constant support so that these meanings may continue to be believable."[8] Isolation or exile, the opposite of social isomorphism--as in the case of an outcast--generally spells death for the individual.

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[7] Dominic A. LaRusso, Mind the Shadows: An Essay on Nonverbal Communication. From the Author, 1971.

[8] Berger, Sociology, p. 64.

Thus far, we have analagously considered the lives of a lost civilization of insects. While we will return to this allegory, our consideration remains with the concept of Weltanschauung. We might describe Weltanschauung as a kind of *perceptual net* in which cultures symbolically underpin chaos. Art and ritual perform this essential function as cultural participants orient themselves to one another while they mediate their essential relationship to the world.

Primary to this battle with chaos is the ordering of human beings within an otherwise chaotic world. As with the Greek tragedy, the stakes are high, the path long, the obstacles many, yet dogged determination remains. "But (man/woman) is an actor, playing a part in the drama of being and, through the brute fact of his (her) existence, committed to play it without knowing what it is...(Furthermore), both the play and the role are unknown. But even worse, the actor does not know with certainty who he (she) is himself (herself)."[9]

Leaving irony to itself, let us reflect upon the foundation of mathematics. The basis of mathematics, as any school-aged child can tell you, is a *set of axioms* ("givens"), which are inexplicable beginning points for theory. The basis for theorizing about the world must be fixed before we proceed with our culturally-guided exploration. Conceptual "footholds" must be evinced by establishing cooperative rules before more abstract goals become definable. Witness young children establishing rules for the game of marbles *before* they proceed with their playful exchange. Psychologist Jean Piaget (The Moral Judgment of the Child, 1965) has explored this rule-making as one of the most powerful of human organizers and motivators.

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[9] Eric Voegelin, *Order and History: Israel and Revolution*, vol. 1 (Louisiana State Press, 1956), pp. 1-2.

Pre-suppositions about the world are self-validating indicators governing how-we-come-to-know-what-we-know as well as what-is-generally-thought-to-be-worth-knowing. The pursuit of the concept of "truth" is of primeval import to the historical rise of civilizations. "Great societies have created sequence(s) of order, intelligibly connected with one another as advances toward, or recessions from, an adequate symbolization of truth, concerning the order of being of which the order of society is a part."[10]

Possession of the "monopoly of existential truth," as the ancient priests discovered, remained essential to the efficient control of masses of people. Belief concerning the basic nature of humanity within the universe (recall our narration of myth) is the axiomatic omega point of culture. The "Codified," legitimated Weltanschauung may lead to nothing less than the comprehensive fixing of belief into comprehensible, believable packages (ideologies). These packages of belief are passed on from generation to generation via socialization. An implicit faith in their certainty (in an a priori fashion) allows us the luxury of avoiding painful Greek tragedy.

However, regardless of the credibility of our authoritative sources, the "hidden agenda" provided by most societies from time to time does come unglued. Societies in transition must suffer the vertigo of "epistemological weightlessness." Ambiguity, ambivalence, and uncertainty prevail, as traditional mainstays of order evaporate. In the words of the poet Yeats: "Things fall apart; The center cannot hold; Mere anarchy is loosed upon the world..."[11]

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[10] Voegelin, Order and History, p. ix.

Without a sophisticated "hidden agenda," societies would lack the cohesiveness necessary to function cooperatively and effectively within the frightening chaos of experience.

> The security cosmology myth (identity including well-integrated World Views) provides, by giving man (woman) a sense of belonging to an alien non-sentient environment and by integrating human organization with the world of nature, is too valuable to be lightly surrendered. By relieving man of the traumatic fears of isolation in a hostile (worse yet--indifferent) universe, it frees them (him/her) for effective and confident living. In this sense, the conservative tendencies of society's mythology have a profoundly important function and should rather be described as 'conservatory.'[12]

A cohesive pattern of commonly shared assumptions makes the linkage between the individual human actor and collectively desired (politically articulated) "oughts" seem more probable. With the guiding compass of Weltanschauungen (-en in the German plural construction), societies would lack conceptual footholds and would fail in the tenuous "grasping" at shared threads of the world.

Weltanschauungen may additionally be considered a kind of red contact lens--a delicately shared fabric of assumed belief. It is the equivalent of a "map without a map," involving everything from questions of being to more mundane assumptions about acts of perception. Consider, if you will, the anthropologist who discovers that his or her "objects" of study--a South Pacific simple egalitarian society--divide the color spectrum in a wholly contrasting way to "ours." Furthermore, the anthropologist discovers that the words for "blue" and for "green" are one and the same. Anthropologists have long known that the color spectrum is divided differently within different cultures. As color perception is culture-bound, should our frustrated investigator consider "the poor devils" colorblind, or is there some other explanation for the lack of a distinction between these two colors?

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[11] William Butler Yeats, "The Second Coming," in Louis Untemeyer, ed., Modern American and British Poetry (San Francisco: Harcourt Brace, 1955), p. 491.

[12] Robin Clarke and Geoffrey Hindley, Challenge of the Primitives (London: Jonathan Cape, 1975), p. 210.

Cultural interface leaves us reaching for assumptions that characteristically limit our perceptual capacities. The "doors of perception," as Huxley has called the wider process of cognition, can assume a frighteningly narrow parameter. Modes of analysis can create more confusion than clarity. Self-evident truths tend to become self-validating as societies fall into unceasing tautologism.

In summary, we have referred to Worldview Weltanschauung as a kind of meaning system in which human identity is organized and is passed along culturally via the conquering of chaos. The psychological and philosophical basis for this communal sharing is via a process of isomorphism, or feeling of oneness with peoples, events, or external things similar in form, structure, or spirit.

The basis for this kinship or drama is the collectively shared unfolding of human being within a socially created reality. Worldview is a socially sanctioned perceptual net which, though guiding the life force of civil society, is itself based upon pre-suppositions and assumptions. These guiding principles or axioms (givens) represent the comprehensive fixing of belief into adequate, hence believable, symbolizations of truth.

Each society, via a reasonably inflexible Worldview, attempts to establish *with certainty* the relationship between individuals, civil society, and the world, hence providing *security* for its members. Thus, a *hidden agenda*, generating codes of moral behavior, including categories of "goods" as well as "taboos." The foregoing tend in a fundamental way to create rules before the game of human perception is allowed to begin.

Worldview is, therefore, a comprehensive package of *perception, meaning, and symbolic interpretation* based upon *belief*. It represents the mind's/minds' attempt at grasping order within an otherwise chaotic universe. As with the most rudimentary of thought systems, philosophy demands structure (form) before meaning (content) becomes manifest.

Now that we have taken a general look at the concept of Worldview Weltanschauung, we will spiral into some of its historical roots. We will find that while its philosophical roots remain ancient, its emergence as a viable concept dates from the early decades of this century. We will move toward an understanding of the concept through its chronological appearance as well as through its various applications. Recall that we are dealing with a concept, as definitive definitions cannot be rightly fixed into rigid place without doing irreparable damage to the concept itself. Therefore, we are attempting to move toward the core of the concept--toward its essence--while we show its relationship to other concepts such as meaning system, identity, being, truth, perceptual net, axioms, belief, etc. Worldview--once set free--will prove to be an invaluable tool in understanding the roots of our ecological and social crisis, and will offer us the possibility of creating new and previously uncharted worlds.[13]

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[13] John Wilson, Thinking With Concepts (Oxford University Press). This is an excellent beginning text. Paperbound and of short duration, the book treats with delicate care the process of conceptual thinking. It is down to earth as well as clear in its elucidation of the problems of thinking about concepts.

See also C.S. Lewis' Studies in Words (New York: Cambridge University Press, 1975), for a discussion of the beauty, usefulness as well as frailty of language. He speaks about the process of "verbicide," or the systematic murder of a word. Concepts, Lewis argues, must maintain a flexibility and breadth of meaning if they are to maintain their vital significance.

B. AN HISTORICAL DEVELOPMENT OF THE CONCEPT OF WORLDVIEW

The emergence and evolution of the concept of Worldview reads rather like a philosophical black hole. The concept unfolds (in varying forms) in German Philosophy, and it moves in horizontal directions into Political Economy (Marx, Engels) and German Historicism. It is greatly expanded in the "Sociology of Knowledge" by Mannheim as well as by the psycho-philosophical exploration done by Jaspers. Worldview receives an entirely new generative impetus within the field of anthropology in general (Kluckhohn) and, regretably, Redfield dies in the process of completing the definitive anthropological sketch. Furthermore, the concept gains momentum within the "Linguistics" philosophy of Wittgenstein and, more recently, it winds up as an important aspect of the critique of Positivistic Science (Kuhn).

While the essential environmental significance of the concept must wait until Sectin C, we will draw from a whole host of authors to clarify most explicitly its murky presence. Peace be unto the reader, we will avoid most (not all!) of the philosophical debate while discriminatingly concentrating upon various usages of the concept.

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Part of the confusion surrounding the concept of Worldview is due to the fact that it has not been used uniformly over time to designate a unified theoretical concept. Instead, it has appeared under various guises,[14] and among a whole host of philosophers for the clarification of questions of entology (being), teleology (the study of final causes, purpose), and epistemology (how we came to know what we know, including its limits: what counts as being "real"?). Using epistemology as a spring board, we will discuss the concept as well as its thorny presence and ultimate usefulness.

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[14] As we shall see in this developmental sketch, various authors assigned refined or more general meanings to the concept. Several of the terms used to reflect a Worldview concept include;

- LEHNBILDUNG (Kant)
- WELTANSCHAUUNG (Dilthey, Mannheim, Jaspers, etc.
- LEBENSFORM (Wittgenstein)
- PARADIGM (Kuhn)

Grimm's Deutsches Woerterbuch attributes the original appearance of Worldview to Kant who, in 1790, used the term "Lehnbildung" (picture of the world).[15] While hints of Worldview are present in Aristotle's Metaphysics, the elucidation of the concept assumes vital significance as part of the German philosophical tradition. Essential to the frames of this debate were questions such as:

- How do we come to know the world?
- What constitutes this process of knowing?
- Can we ever know what is 'real'?
- What is the relationship between Reason and Human History?

Using these questions as guidelines, we will weave a theoretical needle through the German epistemological labyrinth by asking what is really "real"?

Plato argued that one had to look beyond the deceiving world of images in order to really comprehend the essence of the world. Recall that in his cave analogy, one perceived only images of things, such as pencils, tables, and rocks. In other words, touching the objects, taste, etc., hardly helped one to know the world. Indeed, it was quite the contrary. Plato postulated that by remaining chained to the objects, one remained trapped (deceived) by the notion that, through appearances, one could grasp a "reality." Pencil or not a pencil, that is the question...

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[15] Grimm, Deutsches Worterbuch, 14:1, "Weh-Wendunmut" (Leipzig: Verlagvons Hirzel, 1955), pp. 1530-1538.

In his Critique of Pure Reason, Immanuel Kant (1724-1804) responded to the philosophy of Plato and others by addressing the character of human knowledge. Kant believed that there was no direct awareness of sense data. Sense data were, he said, inaccessible to consciousness in their original state. We apprehend a thing-in-itself only as unified by a priori principles or categories of the mind. One could never really know objects, one could only discern how the thing-in-itself appeared.

Central to Kant's theses was that mind is an active and creative agent. Mind, as the sole agent in cognition, does not passively register sensations of the "objective world." Experience is fundamentally shaped by mind. Hence, we will never be able to discern whether the source of our experience corresponds to pencil or to our picture of the external world. world. According to Kant, therefore, our pictures of the world (Lehnbildung) are created by mind, and its transcendental (external and constant) "categories" are conditions of the possibility of experience. As to those who ascribe meaning to "objects-in-themselves," they simply remain subordinate features of things, as they are themselves ensnarled in their own delusions.

Kant had esposued the view that thinking itself was an activity. The mind, engaged in understanding, approches the world with concepts and pre-suppositions of its own. The mind, therefore, does not reflect the world, but tries--actively--to understand and interpret it. This activity of synthesizing could only be done with the concepts one already possesses. The pursuit of knowlege is, therefore, a spontaneous activity in which knowledge and freedom go hand in hand. This view, in contrast to the deductive empiricism of Bacon and Newton, frames a philosophical debate of immense proportion and significance.

The character of this debate could be broken into several schools of thought, each having greater or lesser numbers of adherents through the past several centuries. The School of Idealism basically believed that mind and spiritual values are fundamental in the world as a whole. While Kant called his system of thought variously "transcendental idealism" and/or "critical idealism," he is very critical of the metaphysics of Fichte (1762-1814)[16] and Schelling (1775-1854),[17] and should hardly be considered within their critical frameworks. Idealism, as it later came to be criticized by Marx, was called the doctrine by which mind or spirit was primary in the universe.

Rivaling Idealism and its theory of knowledge was the School of Naturalism. Naturalism espoused the view that mind and spiritual values have emerged from or are reducible to material things or processes. This belief fundamentally attacks the metaphysics of Geist (Spirit) or Mind by asserting positively that the natural world, known and experienced scientifically (via objective, empirical sense data, and rigorous observation) is all that exists.

John Locke (1632-1704) was a leading British empiricist. In Essay on Human Understanding, he argued that the supernatural is not to be trusted and that material, sense experience via perception is the basis for human knowledge. The mind, according to Locke, is the equivalent of a "blank slate" at birth, and knowledge comes accordingly from structured perception of reality. Through a process of observation and experimentation, one could decide inductively what was true and, hence, verifiable.

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[16] For Fichte, a tree, intelligent ego (Ich/I) must be the starting point of philosophy and everything else was deduced from this absolute ego.

[17] Schelling argued that things are always conditioned by other things but that mind was undetermined and hence absolute.

Naturalism advanced the epistemological viewpoint that the human mind, operating naturally, perceives the same things in the same way regardless of time and place. Using the new experimental method of Bacon and Newton, such a view maintains that knowledge based upon experience has an "objectivity" that no other claims to knowledge could possess. Out of classical British Empiricism, such an exclusive claim to knowledge came to be enshrined in the doctrine known as Positivism.

Positivism relied upon the critical assumption that our generalizations about experience are reliable if and only if they are constructed from or tested by the raw material of experience. Furthermore, such a view presumes that the "hard facts" of the external world are given to us prior to our conceptualization. Thus, the "facts" of the external world could be verified as "true" (hence real) or "false," via testable observation.

The objective grounding of truth in sensory experience makes possible the belief that all knowledge could be considered as being true, independent of time, place, or circumstance. Therefore, throughout history the mind and its perceptions, informed by raw data, does not change but remains constant and testable. Truth, according to scientific method, is tucked neatly into the verifiable folds of categorized facts, making the universe intelligible and ultimately "rational." Under the spell of scientific method and absolute verification, Worldview could hardly be considered in the rigorous pursuit of knowledge. Surely, there was no knowledge beyond that which one could grasp...?

The contrast between these divergent philosophical systems, based upon highly varied pre-suppositions, leaves one searching for reconciliation. We must now continue the historical debate with the philosophy of Hegel.

Hegel (1770-1831) argued that "the finite is not genuinely real." Hegel reworked the espistemological foundation constructed by Kant and created a historical Phenomenology of Mind, which showed the process of mind (reason) becoming aware of itself through succeeding historical epochs.[18] For Hegel, reason was the absolute that directs the world. Furthermore, reason unfolds itself in a logical, evolutionary way.

Arguing that a succession of historical epochs reflected a necessary development toward a final historical age, Hegel represented himself as the culmination of all world-historical systems. The world or nature, according to Hegel, could be understood only in terms of unceasing change, rather than through fixity, permanence, or being. Knowledge, accordingly, would be conceived in terms of creation rather than discovery. Worldviews, or theories attempting to underpin absolutely the character of "nature," were seen as individual or social creations, shaped by pre-rational forces. According to Hegel, the mind could never grasp "reality." History, therefore, flowing from a primary cause, is represented by an absolute or transcendental ideal which colors every historical epoch. Thus, societies collectively possess what God is--an absolute spirit (embodied by the state) representing the cumulative content of all human history. Hegel represented history, whereby Spirit upon highly varied pre-suppositions, leaves one searching for reconciliation. We must now continue the historical debate with the philosophy of Hegel.

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[18] G.F.W. Hegel, Phenomonology of Mind, trans. by Lichtheim Baillie (San Francisco: Harper and Row, 1967). Also see Freidricks, ed., The Philosophy of Hegel (New York: The Modern Library, 1954).

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Hegel (1770-1831) argued that "the finite is not genuinely real." Hegel reworked the espistemological foundation constructed by Kant and created a historical Phenomenology of Mind, which showed the process of mind (reason) becoming aware of itself through succeeding historical epochs.[18] For Hegel, reason was the absolute that directs the world. Furthermore, reason unfolds itself in a logical, evolutionary way. Argu-

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[18] G.F.W. Hegel, Phenomonology of Mind, trans. by Lichtheim Baillie (San Francisco: Harper and Row, 1967). Also see Freidricks, ed., The Philosophy of Hegel (New York: The Modern Library, 1954).

While reason remained the catalyst for Hegel's historical design, Karl Marx (1818-1883) reacted to a new set of historical conditions and, borrowing heavily from Hegel, presented a new conception of knowledge as well as a new characterization of the dynamics of civil society. In The Critique of Political Economy, Marx wrote, "It is not the consciousness of men that determines their existence but, on the contrary, their social existence which determines their consciousness."[19] In this age-old debate of "nature versus nurture,"[20] Marx could no longer bear the degradation and poverty produced within early Industrial Europe.

Viewing the transformation of society according to a new set of economic determinants, both Marx and Engels (1820-1895) evolved a new known

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[19] Karl Marx, A Contribution to the Critique of Political Economy, ed. Maurice Dobb, (Davis, DA; International Publishers Co., 1971), pp. 11-12.

[20] We encounter the nature/nurture debate so often that perhaps the meaning should be clarified.

Some political theorists argue that guided by inner essence (being, spirit, etc.), the free human agent guides and shapes his/her individual destiny. They argue that the nature of man/woman determines solely or primarily the character of socially created worlds. For this group of adherents (i.e., the anarchists), meaning is manifest from within.

Others argue that minds come into the world as "blank slates" and that human behavior or consciousness is profoundly or wholly shaped by the structured experience set forth by society (language inclusive). These theorists (i.e., Skinner) argue that inculcation and socialization (nurture) are the prime determinants of human possibility. For this group, meaning is manifest from without.

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as (dialectical) materialism, wherein matter (human activity) was primary to the human universe. According to this theory, the material world determines everything--including the consciousness (total awareness, including Worldview) of men and women. By this view, the content of human thought could be reduced to human activity, and to the social activity brought about by this activity.

The prime determinant of human consciousness, according to Marx and Engels, was with the appearance of economic classes that vied for control of the means of production. Conceptual frameworks and modes of thought are themselves said to be derivatives of the lifestyles of the thinker. "The economic categories are only the theoretical expressions, the abstractions of the social relations of production...The same men who establish social relations comfortably with their material productivity (profit), produce also the principles, the ideas, the categories, comfortable (justifying) their social relations."[21]

Thus, society is pictured as an economic lie in which the proletariat is captive of his/her own ignorance. According to this view, the very limits of the conceptual and evaluative tools of men and women lock them into assured immisuration. They are captive of a passive and non-critical view of the economic and political "realities" about them. Furthermore, theory and evaluative awareness of their condition makes their "socially constructed reality" collapsible and subject to radical change through an inevitable overthrow of the power elite.

One may view the proletariat of Marx and Engels' construct as captive within a given historical and economic "reality." The fact that the members of a particular society have--regardless of their povery--accepted their economic destiny as one bows to fate, makes the rule of the game very significant indeed.

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[21] Karl Marx, The Poverty of Philosophy, Quelch translation (Chicago, 1910), p. 119.

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Marx argued that the role of ideology is to maintain (via misinformation, falsification, distortion, claims to absolute truth, etc.) class privilege. The constructed Worldviews of men/women are themselves necessary contributants to the continued well-being of the economic elite. And, as Mannheim points out, "It seems that behind every theory there lie collective (assumptions) points of view. The phenomena of collective thinking, which proceeds according to (economic) interests and social and ethical and existential situations, Marx spoke of as ideology."[22]

We have thus far moved from the abstract notion that the subjective I (Ich) totally determines the content and form of what consititutes "reality"/knowledge, to the position that material conditions, existing externally and without the subjective volition, determine the shape of what is "real." Noology--or the study of phenomena that are held to be purely mental in origin--is more than a philosophical "stone's throw" from the Empiricism of Locke. We see that, based upon radically differing assumptions, the construction of the world assumes unique proportions relative to theory. More on this point later.

The next great figure contributing to the debate of Worldviews was Nietzsche (1844-1900). Nietzsche argued that there is no possibility for final moral knowledge within the ethical or political realm. Arguing that it is impossible to establish, with certainty, what is just as well as good for man/woman, Nietzsche arrived at a point of absolute and unequivocal epistemological and ontological relativism.[23]

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[22] Karl Mannheim, Ideology and Utopia (New York: Harcourt Brace, 1936), p. 110.

Arguing strongly against notions of transcendental or final truth, Nietzsche presented a humanity that is continuously undergoing development, and hence is in constant change. Within such a fluctuating universe, the search for truth or morality is impossible, and hence absurd. Nietzsche declared that one should create one's own history rather than passively assume codified "truths" handed down by corrupt established orders. Accordingly, Nietzsche asserted that each human being had to create his or her own meaning rather than to live according to the lies of the past. This creative power, this will-to-power was the only force that could uncloak the "aesthetic imperative,"[24] the essence behind which everything else was subordinate.

Out of the philosophy of Kant, Hegel, Marx, Engels, and Nietzsche, flows the major philosophical contribution of Dilthey (1833-1911). Dilthey founded the school known as Historicism. Historicism follows Hegel by arguing that the ordering principles of the mind have varied with the succession of epochs and cultures. Historical inquiry betrays that there is no single view of the objective world (as claimed by Positivism), but instead, only a variety of perspectives or Worldviews. Historicism argues that "truth" is relative, for ideas and customs, as well as institutions, are subject to and conditioned by social and historical factors.

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[23] Relativism refers to the condition where all "truth" is relative to time and place (hence fluid and never absolute) and that all "objective" knowledge is impossible. This view holds that most disagreements in ethics among individuals stem from enculturation in differing ethical traditions.

The problem with relativism is that without a notion of the "good" or the "just," one is hard-pressed to argue against the practices of a demagogue like Hitler. Though the example is extreme, the problem of relativism is not without significance. Essentially, avoidance of this sticky issue led Hegel to argue that history was linear and was moving toward an ever higher plane of "REASON." Not suprisingly, Marx subsumed this cumulative ideal within his concept of the movement of society toward ever "juster" planes.

[24] David Mason, "On Nietzsche's Aesthetics: A Political Re-Appraisal." Masters Thesis (as yet unpublished), Department of Political Science, University of Oregon, Eugene.

Dilthey, who was a biographer, had an intimate understanding of the lives and experience of the actors he was studying. Because of our participation in life, we have the possibility of going behind actors and actions in an attempt to understand (Verstehen) their actions (i.e., reconstructing thoughts and memories, or empathizing with purpose, probable feelings, etc.). As Dilthey remarked: "World Views/Weltanschauungen are not produced by thinking. As far as rationalism can see, the global outlook of an age or of a creative individual is wholly contained in their philosophical and theoretical utterances; you need only to collect these utterances and arrange them in a pattern, and you have taken hold of a Weltanschauung."[25]

Dilthey sought to ground his new philosophy of history in the psyches of historical actors. Thus, an intimate understanding of psychology helps one to underpin the "structural" pattern of experience, and these experiences, to varying degrees, may be formulated into general laws. Dilthey explored the process of how it is that one mind is able to become aware of what goes on in another, which necessitated an understanding of individual as well as collective psyche. Dilthey believed that the intuitive key to understanding human action lay in the Weltanschauungen (Worldviews) of the actors themselves. Weltanschauungen represent the complex of beliefs and judgments, as well as meanings, which owe their presence to the collective psyche as much as to the workings of the individual's psychological past.

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[25] Dilthey as quoted in Kurt H. Wolff, From Karl Mannheim (New York: Oxford University Press, 1971), p. 13.

Dilthey's powerful characterization of history was destined to have a profound impact upon twentieth century thought.[26] It was significant within the formative sociology of Max and Alfred Weber, as well as directly reflected within the work of Karl Mannheim.

Mannheim (1893-1947) was greatly influenced by the Marxian model of class struggle and argued that within each social class there exist divergent modes of thought as well as varying criteria of validity. In Ideology and Utopia (1931), he set out to explore some of these cleavages, arguing that Worldviews accompanying social classes vary according to divergent interests. Furthermore, he asserted that social aspirations are related to social status, role, and position. Following Historicism, Mannheim asked how we may be able to identify "those meaningful existential pre-suppositions" to which intrinsic interpretation remains necessarily blind. Mannheim argued that all ideas, "truth" inclusive, are absolutely related to the historical and social context in which they emerge.

By asserting that knowledge must always be knowledge from a certain position, Mannheim even took on the Marxists, for they maintained that their thoughts were uncolored because of their critical, non-privileged interests. Mannheim was interested in creating a vehicle by which one could study all thought as well as its relationship to society. This primary relationship--where thought and society were constantly juxtaposed--came to be known as the "sociology of knowledge."[27]

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[26] Oswald Spengler (1880-1936), a German philosopher of history, is notably absent from this discussion. In his Decline of the West (1928), he wrote that the key to history lay within the laws of civilizations. He maintained that historical epochs, each with its grand agenda and accompanying Weltanschauung, rose and fell in cycles.

The philosophical problem of relativism (see footnote number 23) was fueled by Dilthey and Nietzsche as well as by the writings of Sigmund Freud. The invention of psychoanalysis by Freud laid the subjective path to a new science of humanity. This exploration led into the depths of being, motivation, values, activity, and dreams, as well as nightmare. It tended to focus upon the relationship between subjective ego (Ich/I) and the "external" world (it). Perception was vital to an understanding of the developmental ego and its unique formative experience from womb to death. Increasingly, psychology came to link the subjective biographies of actors with external social and historical conditions. One's biography could be located within a socially defined universal meaning system. Thus, psychology contributed heavily to the concept of Worldviews, and offered a unique, subjective point of origin from which to reconstruct human nature within civil society.

Among the major psychologists discussing the concept of Worldview, Karl Jaspers (1883-1969) is of most interest. Jaspers attempted a philosophical exploration of the roots of the concept and of its psychological (methodological) significance. In Psychologie der Weltanschauung,[28] Jaspers assumed a rather strict separation between subjective "Ich/I/Ego."

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[27] "Sociology of Knowledge" (Wissenssoziologie) originated with the German philosopher Max Scheler during the 1920's. Aside from the fact that Scheler's work was never translated into English, Mannheim most clearly articulated the "sociology of knowledge" and introduced its powerful implications to sociology proper.

[28] Karl Jaspers, Psychologie der Weltanschauung.

and the objective world. Essentially, he describes the various "frames" in which the mental life of the individual takes place, and which determine the formal characteristics of his(her) mental manifestation.[29] "These frames or Weltanschauungen represent what is ultimate or complete in man (woman) both subjectively as experience, power and conviction, and objectively as the formed world of objects."[30] As Paul Schlipp points out, the term Worldview may refer to "general view of life" and/or "conception of the world." In other words, Worldviews are "the whole of the objective mental content an individual possesses."[31]

While Jaspers explored typologies of Worldviews, his unique contribution rests with the linkages he made between individual attitudes and philosophical-religious systems. In describing the process of a person acquiring closed Worldviews ("Shells"), he describes the process in terms of a kind of "conversion." "Shellbuilding (occurs when) one's way of experiencing the world is mistaken to be the world as such."[32] In such a case, where individuals are delivered into the convenience and security of an airtight Shell (as in religious or ideological conversion), tacit and passive adoption tends to be absolutistic in nature. The absolutist confusion between constructed world (ideology) and THE WORLD enters Existentialism under the guise of "False Consciousness."[33]

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[29] Paul A. Schlipp, The Psychology of Karl Jaspers (New York: Tudor Publishing Co., 1957).

[30] Ibid.

[31] Jaspers, Psychologie, p. 141.

[32] Ludwig B. Lefebra, "The Psychology of Karl Jaspers," in Schlipp, Psychology of Jaspers.

Another impetus for the expansion of a Worldview concept emerged from anthropology. The vastly contrasting character and cultural diversity of perceptual networks (mythical thought systems, etc.) frequently lead anthropologists to use the concept of Worldview. Within anthropology, Worldview most often refers to "the corpus of beliefs about the world shared by the members of a society and represented in their myths, lore, ceremonies, social conduct, and general values."[34]

Anthropologist Walter J Ong offers us a complementary definition. Ong says, "A person does not receive a World View, but rather takes or adopts one. A World View is not a datum, a donné, but something the individual himself (herself) or the culture (s)he shares partly constructs; it is the person's way of organizing from within himself (herself) the data of actuality coming from without and from within. A World View is a world interpretation."[35]

Regardless of the relative weight one assigns to single members of societies, fundamental differences between cultures lead us to contrast the cognitive construct of all societies with their supporting social-attitudinal systems. Generally, the collective expression of a unified cultural heritage is represented within the cosmology of a culture. As

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[33] Heavily influenced by the German philosophical tradition, Existentialism was grounded in Kirkegaard and eventually made its way to Jaspers, Heidegger, and Unamuno. The French character of its later development is unmistakable with Sartre, de Beauvoir, Marcel, and Camus leading the list.

[34] David E. Hunter and Phillip Whitten, eds., *Encyclopedia of Anthropology*, "World View Weltanschauung" (New York: Harper and Row, 1976).

[35] Walter J. Ong, "World as View and World as Event, in Shepard and McKinney, eds., *ENVIRON/MENTAL: Essays on the Planet as a Home* (New York), p. 63.

Clyde Kluckhohn remarked, "It can sometimes be shown how the economic theory, the political theory, the art forms, and the religious doctrine of each society are all expressive of a single set of elementary assumptions."[36]

Hoebel, in his classic treatise The Law of Primitive Man: A Study in Comparative Legal Dynamics, traces the earliest origins of law from the very core of the mythical foundation of societies. What he presents is often an internally consistent, integrated code of ethics that ties human purpose tightly into divine, universal will. Laws, then, and their etiology, may be seen as a kind of "common law" Worldview, in which societies organize and structure human possibility.[37]

Thus far, we have scanned the development of Worldview/Weltanschauung as an integral part of German philosophy. We have seen that the concept was greatly expanded by German Historicism and, via political economy, found its way into sociology proper. Furthermore, psychology and anthropology gave to Worldview a breadth of meaning never before possible. In closing our historical discussion we will touch upon Wittgenstein's contribution (language and philosopy) and conclude with Kuhn's discussion of the concept of "paradigm."

Ludwig Wittgenstein (1889-1951) was among the earliest and most influential philosophers of language who fundamentally reinterpreted our understanding of, as well as construction of, the world. Rejecting traditional philosophical discussions about the nature of "reality,"

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[36] Richard Kluckhohn, ed., Culture and Behavior: Collected Essays of Clyde Kluckhohn (Riverside, NJ: Macmillan Co., 1965). See also Kluckhohn's Mirror for Man (Greenwich, CT: Fawcett, 1961).

[37] E. Adamson Hoebel, The Law of Primitive Man: A Study in Comparative Legal Dynamics (Harvard University Press, 1954).

Wittgenstein chose to analyze the language that philosophy used in speaking about the world. He assumed, among other things, that elementary linguistic (symbolic) propositions could be (logically) equated with associated objects in the "real world." Furthermore, he maintained that there was one and only one "ideal language" in which philosophical discourse could be cast.

In the course of his development, Wittgenstein arrived at the conclusion that "experience receives its meaning from language."[38] Language, he argued, wholly guides us in our perception of the world. In other words, we "know" the world as set forth by the language we speak. "What has to be accepted, the given, is--so one could say--forms of life."[39] Lebensform, as the equivalent to Worldview, is embodied in the language (hence custom) of a culture. Human thought--itself subordinate to language--limits the conceptual possibility relative to the delicate fabric of our language. Such a theory, taken to its sociological limits by Sapir and Whorf, states that all views of reality are determined in an unconscious manner by the linguistic systems of culture. Such a valuable linkage, according to Peter Berger, cannot be lightly surrendered. Berger writes:

> This socially determined World View is, at least in part, already given in the language used by the society. Certain linguists may have exaggerated the importance of this factor alone in creating any given World View, but there can be little doubt that one's language at least helps to shape one's relationship to reality.[40]

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[38] See Wittgenstein's Philosophical Investigations, Anscombe translation (New York: Macmillan, 1953), as well as his Blue and Brown Books (New York: Harper, 1958) for this, the final rendering of his thoughts.

[39] L. Wittgenstein, Philosophical Investigations, p. 226

[40] Berger, Sociology, p. 117.

Language is therefore invaluable in considering Worldviews of individuals within socially constructed worlds of mutual activity.

Another way of considering Worldview was set forth by Thomas Kuhn in *The Structure of Scientific Revolutions*.[41] Kuhn describes the evolution of scientific development as a shift from one "*paradigm*" to another. As with the Historicist, science analogously compares to a sequence of epochs, one coming after the next, in which truth remains relative. Each epoch or paradigm, with its distinctive accompanying Worldview, tends to be highly rigid in its pre-suppositions. Furthermore, scientific "shells" tend to be highly selective in the questions and hypotheses they wish to entertain, and also tend to be generally closed in the data acceptable to their self-serving verification. It is, in other words, based upon the principle of IGNOR-ANCE for, in a manner of speaking, it ignores everything contrary to or conflicting with its very premises.

The "incommensurability" of scientific paradigms stems from their self-evident and self-contained natures. And, as Kuhn argues, *a drastic change in scientific thought occurs when one paradigm is replaced by another*. In a manner of speaking, a new paradigm requires that all of the 'givens' must be reconsidered. Finally, and perhaps most interestingly, *in order to arrive at a new paradigm, one must transcend "acceptable" modes of reasoning and analysis*. Instead of serving as a "paradigm maintainer," one must suspend belief in "ordinary" modes of perception. *To wield a tool, one must grasp it from the outside*, and the quantum leap to new paradigms occurs largely via transcendental/intuitive insight or by historical accident. Resulting is the creation of new conceptual understandings, as well as a flurry of new questions that may simultaneously appear.

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[41] Thomas Kuhn, *The Structure of Scientific Revolutions*, 2nd edition (Chicago: University of Chicago Press, 1970).

Positivistic science, as one of many possible paradigms or "creations," becomes vulnerable to reappraisal, and its "world-taken-for-granted" must be collapsed. Paradigms predefine for us the form as well as the range of our scientific questioning, "in the same way, society supplies our values, our logic, and the store of information (or, for that matter, misinformation) that constitutes our 'knowledge.' Very few people, and only in regard to fragments of this Worldview, are in a position to reevaluate what has thus been imposed upon them. They actually feel no need for reappraisal because the Worldview into which they have been socialized appears self-evident to them."[42]

This concludes our historical appraisal of the concept of Worldview. However sketchy it appears, we are much closer to a fuller appreciation of its environmental significance. An ideal environmental Worldview is the aim of Section C of this essay, as we discover that the operational ideals (Worldview) of Western Industrialism collapse on ecological and human planes.

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[42] Berger, Sociology, p. 117.

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C. STEWARDSHIP AS A WORLDVIEW

We of the industrialized twentieth century are the confident Winter Insects of our opening analogy. We are the whole new breed who, since the Copernican (r)evolution, have created a highly efficient model of technological transformation. We are the breed who have successfully wed scientific insight with technical mastery and productive compulsion. We are the *masters* of a materialistic Worldview that subordinates all other forms of life to our formula of production. We are inheritors of the legacy that "man is the measure of all things..." We are the sole evaluators of *the painful evidence of success*.

Consider several of the "Problems of Success" that Willis Harmon claims have accompanied the advances produced by the techological-industrial era.[43] (See Figure 1.)

As one scans the scoreboard, one is hit with the enormous complexity of the crisis at hand, as well as its creative potential. The greater our dramatic *control* or *dominion over* nature, the more severe the hazard for potential ramifications. Likewise, the greater our sense of power, the more intense our feelings of powerlessness. We alone, perhaps in the history of the human race, possess the capacity to comprehend what is happening as a consequence of the apparent course of events. "We alone can untangle the terrible paradox of PROGRESS which gives us this world where things get worse as they get better."[44]

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[43] Willis Harman, "The Coming Transformation in Our View of Knowledge," *The Futurist* (June 1974), p. 127.

[44] Theodore Roszak, *Where the Wasteland Ends* (Garden City, NY: Anchor Books, 1973), p. xxii.

"SUCCESSES"	RESULTING PROBLEMS
Prolonging the life span	Regional overpopulation; problems of the aged
Highly developed science and technology	Hazard of mass destruction through nuclear and biological weapons
Advances in communication and transportation	Increasing air, noise, and land pollution; information overload; vulnerability of a complex society to breakdown
Efficient production systems	Dehumanization of ordinary work
Affluence	Increased per capita consumption of energy and goods, leading to pollution and depletion of the earth's resources
Satisfaction of basic needs	Worldwide revolutions of "rising expectations"; rebellion against non-meaningful work
Expanded power of human choice	Unanticipated consequences of technological applications
Expanded wealth of developed nations	Increasing gap between "have" and "have-not" nations; frustration of the revolution of rising expectations

Figure 1. THE PROBLEMS OF SUCCESS (Harman, 1974)

As if the problem of discovering where we are is not enough, there are also fundamental perceptual difficulties associated with the "so-called" environmental/social crisis. Accompanying certain interests in society (e.g., Mannheim, Marx) is a certain Worldview, with its inherent limits, purpose, and design. Accompanying the research scientist (e.g., Kuhn), is a certain Worldview, or "paradigm," which defines for the experimenter the modes of verification, kinds of questions to be asked, etc. Furthermore, leaders or those who play critical roles in our society are deferentially given the title of "expert."

What is important for us to know is that leaders too are operating from a Worldview in deciding upon what is important, what is "just," what is idolatry, etc. Rather than asking the question of how they decide what they decide, let us take an example of the interface of Worldviews in the assessment of the environmental "limits to growth." (See Figure 2.)

Our example comes from Herman Kahn's book, Toward the Year 2000.[45] In it he and his co-authors contrast the Worldviews of four archetypal perspectives of the American "growth" debate. Important in this contrast is the interface of the assumptions, values, and attitudes that are themselves derivatives of a certain Worldview. For the sake of brevity, we will present the most highly antagonistic perspectives and will let the reader do the bulk of the contrast. (And should stereotypes be necessary, for Category A, "Convinced Neo-Malthusian," substitute "rabid ecologist." For Category B, "Technology and Growth Enthusiast," substitute "capitalist running-dog-engineer."

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[45] Herman Kahn, et al., Toward the Year 2000 (New York: Macmillan, 1967), pp. 10-16.

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-A- Convinced Neo-Malthusian	-B- Technology and Growth Enthusiast
1. BASIC WORLD MODEL	
Finite pie. Most global nonrenewable resources can be extimated accurately enough (within a factor of 5) to demonstrate the reality of the running-out phenomenon. Whatever amounts of these resources are consumed will forever be denied to others. Current estimates show we will be running out of many critical resources in the next 50 years. The existing remainder of the pie must be shared more fairly among the nations of the world and between this generation and those to follow. Because the pie shrinks over time, any economic growth that makes the rich richer can only make the poor poorer.	Unlimited pie. The important resources are capital, technology and educated people. The greater these resources, the greater the potential for even more. There is no persuasive evidence that any meaningful limits to growth are in sight--or are desirable --except for population growth in some LDC's. If any very long-term limits set by a "finite earth" really exist, they can be offset by the vast extraterrestrial resources and areas that will become available soon. Man has always risen to the occasion and will do so in the future despite dire predictions from the perennial doomsayers who have always been scandalously wrong.
2. TECHNOLOGY AND CAPITAL	
Largely illusory or counterproductive. Proposed technological solutions to problems of pollution or scarce resources are shortsighted illusions that only compound the difficulties. Even on a moderate scale this approach would only further deplete crucial resources while avoiding the real problems and prolonging the poverty of the LDC's. Any future economic development should be restricted to the Third World and should include some transfer of existing capital assets from the overdeveloped nations. A completely new approach is needed for the long term.	Solves slmost all problems. Some current problems have resulted from careless application of technology and investment, but none without a remedy. It is not paradoxical that technology which caused problems can also solve them --it only requires mankind's attention and desire. There is little doubt that sufficient land and resources exist for continual progress on earth. Most current problems are the result of too little technology and capital, not too much. In any case, man's desire for expansion into new frontiers will lead eventually to the colonization of the solar system and effectively unlimited lebensraum.

Figure 2. EXAMPLES OF TWO DIVERGENT WORLDVIEWS (Kahn, 1967)

What is remarkable about both perspectives is that, given access to similar information, the two perceivers arrive at radically opposing conclusions. For one group (A), technology and its accompanying growth paradigm is the nemesis as well as the precipitator of the environmental-social crisis. For the other (B), technology is the vehicle that delivers the "unbound prometheus" upward into a bold new future. For the first (A), collapse, starvation, and war are but a few of the inevitables in the self-destruct equation. The second (B) subordinates potential conflict to human inventiveness as well as economic development.

At this point, it seems only right to proceed with an analysis of the positions of the Neo-Malthusian and the Technology-Growth Enthusiast. After careful weighing, in light of acceptable evidence, the reader must then decide where, upon the continuum (or fence) he/she sits, and why.

Rather than begin this process, we prefer to let the reader decide for him or herself, given the tumultuous ecological and industrial evidence. Instead, we will continue with some fundamental assumptions:

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ASSUMPTIONS:

1. The Industrial Worldview/Paradigm and its supporting political, economic, technological, and ethical "machinery," cannot help us to comprehend nor transcend the destructive precipice faced by Western industrial culture.

2. Furthermore, the Industrial Worldview/Paradigm is, with its accompanying value structure, most directly responsible for the dilemma of world ecological and social collapse.

3. Western industrial culture is undergoing a metamorphosis in its basic cultural premises, including a fundamental redefinition of "man/woman-in-society" and "man/woman-in-the-world."

4. "The industrial world is simultaneously undergoing a conceptual revolution as thoroughgoing in its effects as the Copernican Revolution, and an institutional revolution as profound as the Industrial Revolution."[46]

If a modern industrial Worldview is responsible for our malaise, then it would be wise to think around it. This leaves for us, as theorists, the task of redefining what the essential concerns, questions, and "images" of human beings in the world should (be)come.

The need for ethical and political theory becomes most acute in times of political crisis when the operating paradigm (Worldview, with its corresponding values and assumptions) of society effectively ceases to function. If, according to Hegel, "freedom is the recognition of necessity," and necessity demands a recognition of the "limits to growth" as well as the poverty ("affluent squalor") of modern materialistic life, then change becomes more than mere prescription. Change as communicated through new emerging Worldviews, or "images," becomes the generating ideal by which one grasps at "what seems" rather than toward the stultifying (what) "is."

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[46] Willis Harmon, "The Coming Transformation," The Futurist, (April 1977), p. 106. Assumptions #3 and #4 are found in Harmon's work, as are other shared similarities within this essay. For a more complete picture of Harmon's work, see Harmon, et al., Changing Images of Man, Stanford Research Institute Center for the Study of Social Policy, Policy Research Report #4, May 1974.

As with the utopian novel, comprehensive images of possibility are the generative vehicles for mobilization. Personal "response-ability"--itself a product of knowledge, insight, and concern--frees us to act upon the promise of a better life to come. By now, the necessity for alternative "images of man/woman" must seem clear, along with the significance of Worldview in ecological thinking. It remains for us to construct or conjure up a life-supporting and life-sustaining environmental Worldview that places humans within nature and that reemphasizes the concept of a fellowship of man/woman. Out of the ashes of the old industrial paradigm must grow the delicate threads of a new vision of the possible. Within such a vision, the "rights of rocks" must be considered alongside the value of personal growth and community-oriented, humanly-scaled technology. Within such an ideal vision, the perception of desirous environmental and social "goods" must be united with belief as well as action. Let us consider one such possible vision of "the future" as we reflect upon the archaic and dangerous assumptions of its industrial precursor. (See Figure 3.)

What is Voluntary Simplicity? Mitchell Elgin describes it as follows:

> The essence of voluntary simplicity is living in a way that is outwardly simple and inwardly rich. This way of life embraces frugality of consumption, a strong sense of environmental urgency, a desire to return to living and working environments which are of a more human scale, and an intention to realize our higher human potential--both psychological and spiritual--in community and ourselves. The driving forces behind voluntary simplicity range from acutely personal concerns to critical national problems ...Voluntary simplicity is important because it may forshadow a major transformation in the goals and values of the United States in the coming decades.[47]

Willis Harman has identified two guiding ethics which, in varying ways, underpin this social movement. The first emphasizes "the total

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[47] Duane S. Elgin and Arnold Mitchell, "Voluntary Simplicity: Life-Style of the Future?" The Futurist (August 1977), pp. 200-201.

INDUSTRIAL WORLDVIEW	VOLUNTARY SIMPLICITY WORLDVIEW
VALUE PREMISES	*VALUE PREMISES*
Material growth Man/woman over nature; Competitive self-interest; Rugged individualism; Rationalism	Material sufficiency coupled with psycho-spiritual growth; Man/woman within nature; Enlightened self-interest; Cooperative individualism; Rational and intuitive
SOCIAL CHARACTERISTICS	*SOCIAL CHARACTERISTICS*
Large, complex living and working environments	Smaller, less complex living and working environments
Growth of material complexity	Reduction of material complexity ("Emphemeralization")
Identity defined by patterns of consumption	Identity found through inner and interpersonal discovery
Space-age technology	Appropriate ("intermediate") technology
Centralization of regulation and control at national/state level	Greater local self-determination coupled with emerging global institutions
Specialized work roles--through division of labor	More integrated work roles (e.g., team assembly, multiple roles)
Secular	Balance of secular and spiritual
Mass produced, quickly-obsolete standardized products	Handcrafted, durable, unique products
Lifeboat ethics in foreign relations	Spaceship earth ethics
Cultural homogeneity, partial acceptance of diversity; High pressure, "rat race" existence	Cultural heterogeneity, eager acceptance of diversity; "Laid back," relaxed existence

Figure 3. CONTRASTS BETWEEN THE INDUSTRIAL WORLDVIEW AND THE WORLDVIEW OF VOLUNTARY SIMPLICITY

community of man-in-nature" and the second recognizes the "oneness of the human race." We will take them in their order of appearance.

The man/woman-in-nature can be called the ecological ethic. As defined by Lynton Caldwell, such an ethic "recognizes the limited nature of resources, sees man (woman) as an integral part of the natural world, hence inseparable from its governing processes and laws. The ecological ethic fosters a sense of the total community of man (woman) and of future generations."[48]

Arbitrary human design clearly falls short of the mark, as our self-proclaimed mastery over nature suggests. "As we progress from descriptions of fauna and flora, of cycles and pyramids, of stability and dynamism, on to intricacy, planetary opulence and interdependence, to unity and harmony with oppositions in counter point and synthesis, arriving at length at beauty and goodness, it is difficult to say where the natural facts leave off and where the natural values appear."[49] From the experience of such a knowledge, Aldo Leopold writes, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community."[50]

What we must learn is that before we can properly transcend our supposed dominion over the earth, we must extend the franchise to include rocks. Previously, it was asserted that "our ethical heritage largely attaches values and rights to persons, and if nonpersonal realms enter, they enter only as tributary to the personal. What is proposed here is a broadening of value, so that nature will cease to be merely "property" and become (instead) a commonwealth."[51]

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[48] Lynton Caldwell, Environment: A Challenge to Modern Society (New York), p. 110.

[49] Holmes Rolston III, "Is there an Ecological Ethic?" Ethics, 85:2 January 1975), p. 101.

[50] Aldo Leopold, "The Land Ethic."

What we must do is to "universalize person"--to embrace the WHOLE of the commonwealth of life. Instead of maintaining our presumed dominion, should we not recognize the "souls" present in rocks, trees, mountains and rivers? As the predominant assumption of subject/object recedes into the scientific past, our enfranchised rocks assume more and more the character of a "Thou" with their own "live presence." In such a world, the pantheon swallows humanity as one participant of tens of thousands. In such community of life, human freedom soars to transcendental heights as human design approaches ecological completeness. Stewardship--or enlightened, kindly use of the earth as well as reverence for its essence or spirit--that is the enormous response-ability and burden that we bear. The whole in all its rhythms, harmony, and dynamic flux is truly greater than the sum of its parts.

The second condition of Voluntary Simplicity may be called "realization ethic." Such an ethic asserts that, "the proper end to all individual experiences is the further development of the emergent self and of the human species."[52] In other words: resolved, society must mirror human needs. Human needs, however, (as Maslow correctly pointed out) also include what we can loosely call the spiritual. Awareness of self, development of creativity, meaningful participation in work as well as one's community are all essential aspects of self-realization.

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[51] Holmes Rolston III, "Ecological Ethic," p. 101. Thanks to Holmes for his penetrating use of the concept of universalized person.

[52] Willis Harmon, "The Coming Transformation," p. 110.

Participatory democracy or self-determination by individuals as members of communities is an important corrollary to this creative ethic. Just as "spirit is seen to realize itself" in human creation of any (meaningful) proportion, the human being must fully and actively participate in the unfolding of a world we can loosely call--"artistic." Be it a person sculpting wood or someone welding a structural frame, the activity must fit into a humanly-scaled, meaningful, and intrinsically worthwhile process. This self-actualizing process approaches a higher human consciousness when being is celebrated rather than passed off as though a curse--via mastery, dominion, and presumed control.

If we can characterize the evolution of the individual in a phrase--"I AM"--then we can characterize the essence of community as--"THOU ART, THEREFORE I AM." Participation in HUMAN BEING makes one equitably open to the human condition and develops a sense of empathy and oneness for the whole of human life.

Furthermore and increasingly, the resources of the tiny "Island Earth" are becoming taxed beyond recognizable limits. If we are able to create new bounds in regard to population, etc., it will only be through the philosophy of Gandhi's "welfare/sarvodaya"--or not wanting what the least of the inhabitants of this earth cannot have.[53] Affluent squalor is intolerable in the eyes of hungry children. "Oneness of the human race" means that population and resource depletion is everyone's problem, including those guilty of "affluent squalor."

In conclusion, Worldview Weltanschauung offers us a valuable conceptual tool for grasping the essence of the human dilemma. It offers us the possibility of assessing our path to the present, as well as considering the imminent peril our eco-world faces given certain, previously "successful" assumptions about the human use of the earth. Further, it offers us a valuable means of considering new (actually ancient) ways of perceiving and organizing our social worlds to be in step with ecological harmonies. The mystery of participation in the whole of the cosmic drama leaves the bare, unadored "facts" of the world lifeless and sterile--apart-from, rather than a-part-of, the grand cosmic scheme of things. In considering the task at hand, as well as the dance we must choreograph, we turn to the poets, for they understand understanding...

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[53] Elgin and Mitchell, "Voluntary Simplicity," p. 202.

> I'd rather learn from one bird how to sing than
> teach ten thousand stars how not to dance.
>
> E.E. Cummings

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SOME PERENNIAL WRITINGS

Plato	The Republic
	Phaedo
Kant	Critique of Pure Reason
Locke	Essay on Human Understanding
Hegel	Phenomenology of Mind
	Philosophy of History
Fichte	The Characteristics of the Present Age
Schelling	System of Transcendental Idealism
Marx, (Engles)	The Critique of Political Economy
	"The Communist Manifesto"
Nietzsche	The Use and Abuse of History
Dilthey	Gesammelte Werke

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FUNDAMENTAL
CONCEPTS
OF
ENERGY

A. INTRODUCTION

We hear the term "energy" constantly in the media. We know, intuitively, that there is something "out there" (and inside as well) that keeps our whole process of activity and involvement going every day. We feel that energy is something definable, yet it constantly resists being pinned down by a definition that is agreeable to everyone. In this discussion we will be content with the explanation that energy is a capacity, a capacity to do work or bring about change.

Most systems are built and maintained by a combination of natural and developed energy resources. Energy, in this context, includes not only the natural and humanly developed sources, but also materials, goods, and services that contain energy in many forms. When energy resources are plentiful, most systems increase their assets and growth; when energy resources are in short supply, activities decline and the systems use available energy for maintenance rather than growth or construction.

To explain and evaluate work-producing systems, the Principles of Thermodynamics were developed by scientists in the early 1800's to encompass the entire realm of natural and human energy systems and their interactions. The Principles of Energetics have been explored and recently expanded by designers and scientists such as Howard T. Odum, at the University of Florida, and Wilson Clark, Office of the Governor, State of California.

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B. THERMODYNAMICS

Thermodynamics, from the Greek roots therme--heat, and dynamis--power, is an applied science that defines and interprets the relationships between energy, heat, and work.[1] The principles of thermodynamics arose when it was found that energy conversions vital for the maintenance of the energy systems of humanity and nature obey certain laws, regardless of the process or energy source involved. These principles must be taken into account when describing the behavior of any system using energy in any of its forms.

1. The First Law

Energy is neither created nor destroyed; or, *"the energy of the universe is constant."*[2]

The First Law of Thermodynamics was established after the British scientist James Joule measured the exact relationship between heat and work. This law shows the basic conversion from kinetic energy to heat. It accounts for the heat generated by friction and motion in work. The first law is also called the Law of Conservation of Energy.

We have heard this law restated recently in these terms: "You can't get something for nothing;" and "There is no such thing as a free lunch."

2. The Second Law

In energy processes, there is a continuous degradation of energy from higher or lower forms.

The Second Law of Thermodynamics is the most important to the development of efficient energy resource delivery. It is also called the Principle of Energy Degradation or the Entropy Law.

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[1] Wilson Clark, Energy for Survival, (Garden City, N.Y.: Anchor Press/Doubleday, 1974), p. 9.

[2] Barry Commoner, Poverty of Power, (New York: Alfred A. Knopf, Inc., 1976), p. 28.

The first law tells us that the energy of the universe is constant. However, in any real process, some potential energy becomes lost. It is degraded from a useful form of energy capable of driving a function, to a form that has lost that capability.

The Second Law of Thermodynamics was developed by the Frenchman Carnot while testing the efficiency of heat engines. He discovered that for the most efficient steam engine, heat should be supplied at the highest possible temperature at the heat source, and should be rejected at the lowest possible temperature at the heat sink, or point of energy loss.

Figure 1. presents a simple diagram illustrating Carnot's principle.

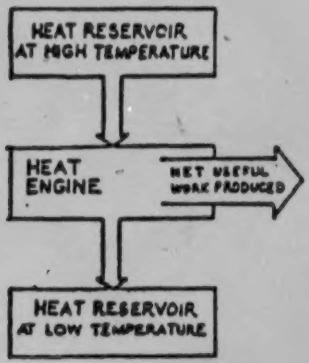
HEAT RESERVOIR AT HIGH TEMPERATURE
HEAT ENGINE
NET USEFUL WORK PRODUCED
HEAT RESERVOIR AT LOW TEMPERATURE

Figure 1. HEAT ENGINE (STEAM) CYCLE AS AN ILLUSTRATION OF THE LAW OF ENTROPY

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[3] Adapted from Clark, Energy for Survival, p. 11.

It is important to our discussions that we acknowledge the role of thermodynamics as a valuable tool for asking the right questions about energy delivery and use. We live with the assumption that energy in its various forms is good for something, that it is essential in performing certain work-requiring tasks. Thermodynamics requires that we question the nature of the assumption by asking: What are certain energy forms good for? Thermodynamics requires that we ask questions about the relationship between an energy resource and the work it performs. For instance, how much of the energy resource is converted to work, and how much is lost to heat or light?

The concepts outlined in the laws of thermodynamics give us the capability of measuring the two basic attributes of energy--its quantity, and its ability to do work. Our purpose in studying thermodynamics is to help us learn how energy can be most efficiently matched to work-requiring tasks. As Commoner puts it: "The practical value of thermodynamics is that it can teach us how to mobilize energy and most effectively use it to generate the activities of civilized life."[4]

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[4] Commoner, Poverty of Power, p. 24.

C. A SYSTEM OF ENERGETICS

The laws of thermodynamics provide us with an energy focus with which to examine the larger systems of nature and humanity. However, it is useful to remember that thermodynamics is just one aspect of this larger picture. There are general principles of energetics based on these two important laws that will allow us to expand our representation of energy concepts.

In order to help us visualize energy principles and the behavior of whole energy systems, a set of symbols has been developed by Odum and Odum[5]. These symbols are based on the most common entities and activities found in all systems that possess resources and utilize energy.

The symbols and the energy processes they represent are presented in Figure 2. The use of these symbols to depict the four major operations of energy systems is presented in Figure 3.

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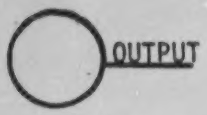
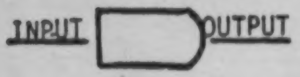
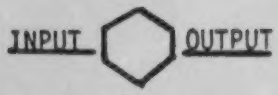
[5] Howard T. Odum and Elizabeth C. Odum, Energy Basis for Man and Nature, (New York: McGraw-Hill Book Co.,1976).



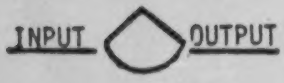
- Sources of direct or stored energy from outside a system (e.g., sun, river, geysers, wind, fossil fuels)



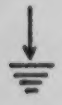
- Production subsystem involving photosynthesis activities (farms, forests, coral reefs, biological communities of streams)



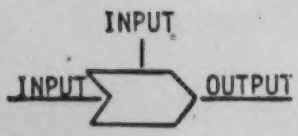
- Consumer system using energy produced; self-maintaining system (people, animals, households, cities)



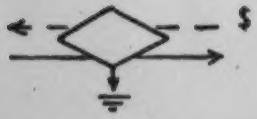
- Storages of energy within a system (water tank, oil tank, library, manufactured structures)



- Energy sinks (losses, wastes, degradations, dilutions, heat)

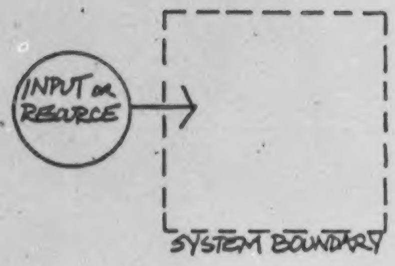


- Interaction of energies flowing along pathways (for example, in mining--interaction of sunlight, water, vegetation, machinery, and people to produce coal)

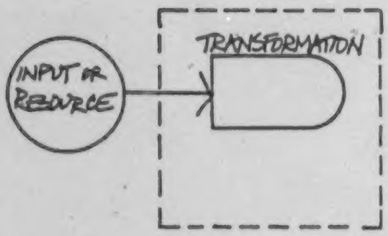


- Flow of money in one direction to pay for energy

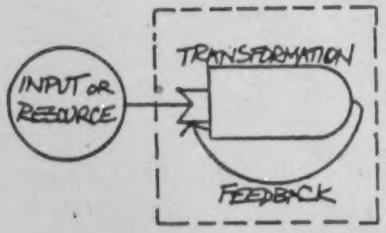
Figure 2. ENERGY PROCESSES AND THEIR REPRESENTATIVE SYMBOLS


INPUT OR RESOURCE
SYSTEM BOUNDARY

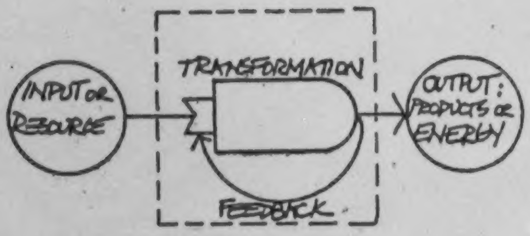
- Input operations that provide resources for the interactions between the system and its environment. This is accomplished by the identification of system-relevant input, and the introduction of input into the system, resulting in activation of the system.


INPUT OR RESOURCE
TRANSFORMATION

- Transformation implies operations that bring about conditions by which the input will be transformed into the output.


INPUT OR RESOURCE
TRANSFORMATION
FEEDBACK

- Feedback and adjustment provide for the analysis and interpretation of information relevant to the assessment of the output and, if indicated, the introduction of adjustments in systems operations in order to bring about a more adequate output.


INPUT OR RESOURCE
TRANSFORMATION
FEEDBACK
OUTPUT: PRODUCTS OR ENERGY

- Output processing implies operations that provide for the identification and assessment of environment-relevant output, and interaction between the system and its environment to introduce the output into the environment.

Figure 3: THE FOUR MAJOR OPERATIONS OF ENERGY SYSTEMS

A simplified diagram of some parts of a coal mining system is presented in Figure 4.

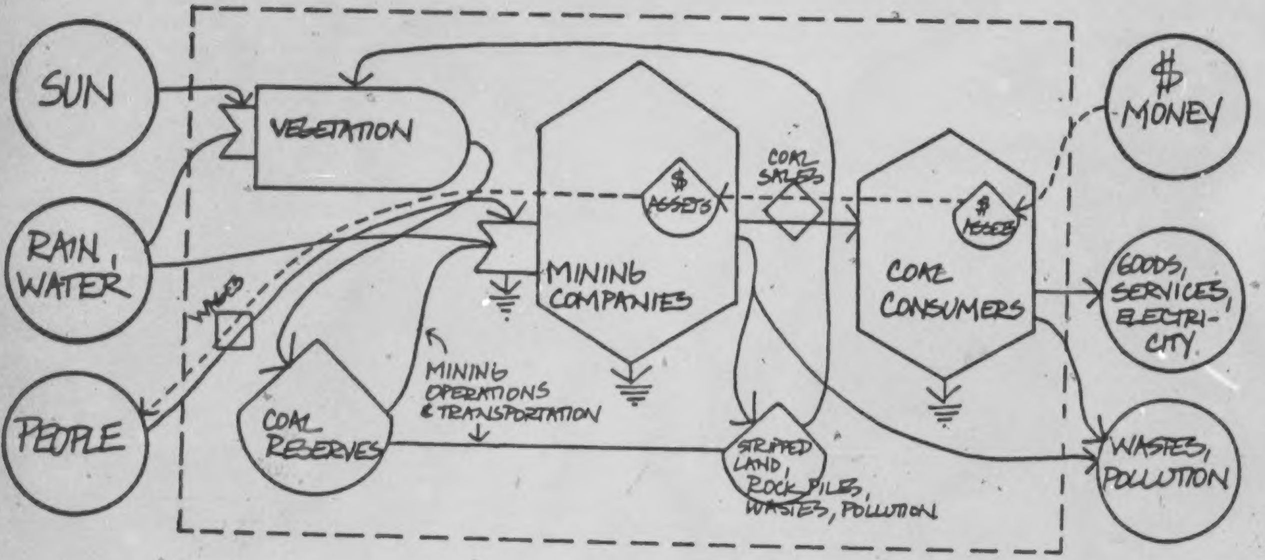

SUN
VEGETATION
RAIN, WATER
PEOPLE
WAGES
COAL RESERVES
MINING OPERATIONS & TRANSPORTATION
MINING COMPANIES
$ ASSETS
COAL SALES
COAL CONSUMERS
$ ASSETS
$ MONEY
GOODS, SERVICES, ELECTRICITY
WASTES, POLLUTION
STRIPPED LAND, ROCK PILES, WASTES, POLLUTION

Figure 4. A COAL MINING SYSTEM

Coal is produced by the deterioration and compaction of organic materials. It is mined, then shipped by barge or rail to be used in power plants (coal consumers). Pipelines that carry slurries (coal and water) of coal are often used instead of railroads as a means of transportation. Coal burning creates by-products, such as ash or acid vapor from smokestacks, which must be dispersed. These pollutants have residual effects on the surrounding landscape and architecture.

Based on these energy operations and the Laws of Thermodynamics, H.T. Odum outlines four major principles of energetics:[6]

1. Feedback Interaction

   The feedback of stored energy acts to help pump in more energy. The feedback is high-quality energy that is amplified by interacting with the energy source. The storage is a necessary feature of controlling the feedback pumping action. Used energy, no longer usable for work, flows from each process and from depreciation of the storage.

2. Material Cycle, Order, and Disorder

   "When Humpty Dumpty converted his potential energy of position first into kinetic energy of falling and then into the heat of impact and the mechanical energy of scrambling, he was pursuing the inevitable course that all things take. Furthermore, although in theory it is possible to restore Humpty to his original condition through appropriate inputs of energy, in practice there is no way to unscramble a scrambled egg."[7]

   Materials move along with the energy from a disorderly state, interacting with an energy source to develop orderly products in storage. As required by the law of energy degradation (the second law of thermodynamics), energy storages disperse concentrated energy into a diffuse or disorderly state, as indicated in the quote above.

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[6] Howard T. Odum, "The Ecosystem, Energy and Human Values," Zygon, 12:2 (June 1977), pp. 112-117.

[7] Carol E. Steinhart and John S. Steinhart, Energy: Sources, Use and Role in Human Affairs, (North Scituate, MA: Duxbury Press, 1974), p. 49.

Entropy is a term derived from a Greek word meaning transformation.[8] This term describes the process that causes available energy to continuously change to a lower form. In entropy terms, the Second Law of Thermodynamics can be restated as follows: The universe tends toward the state of maximum entropy. Clark calls entropy the "energy gravity" of the universe.[9] This principle is used to describe the behavior of all the systems of nature and humanity.

Entropy is a measure of the unavailability of energy for work. It is a measure of a system's tendency toward disorder, dispersion of energy, and loss of information.[10] Clark likens a deck of cards to a system representing order, or low entropy.[11] It has a high stock of potential energy. When the cards are scattered, it would require more energy to pick them up and rearrange them into a deck again than the original energy it took to scatter them. When they are on the floor, they are in a state of high entropy.

3. Energy Quality Chain

Energy quality is a measure of the potential of a substance to do work. Higher quality energies such as electricity have been upgraded a great deal in order to increase this potential. The quality of an energy form refers to the diversity of different purposes it can be used for; energy forms of higher quality exhibit greater flexibility. For example, electricity is much more versatile an energy than sunlight or wood; top carnivores in food chains are more versatile in their feeding habits and services to the system than are the algae or the primary consumers.

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[8] Clark, Energy for Survival, p. 12.

[9] Ibid., p. 13.

[10] Commoner, Poverty of Power, p. 29.

[11] Clark, Energy for Survival, p. 14.

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Figure -5 depicts an energy chain typical of those that are found in food chains in ecology, occupational chains in industry, and chains of physical processes in the ocean and atmosphere.[12] At each state, energy is transformed to a new type that is capable of feeding back as a multiplier. In achieving higher quality energy and ability to control, energy is used and leaves the chain through the used-energy arrows to the heat sinks. There may be no more than 10 percent of the entering energy remaining beyond each transformation, but the quality increases with each step. In a long chain there may be ten thousand calories of low-quality energy such as sunlight converted into one calorie of high-quality energy such as electricity. On the left, flows are large (as measured in calories of heat equivalence), whereas the flows on the right are few in calories but large in impact, acting as an amplifier when they feed back.

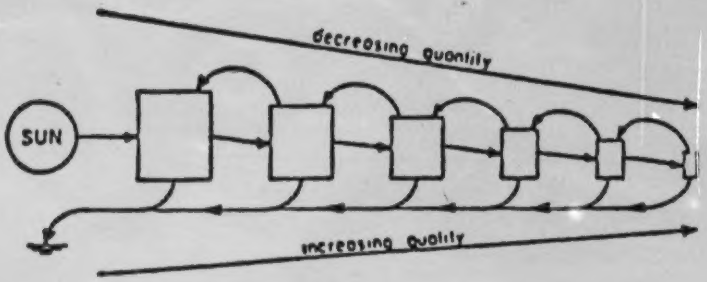

Figure 5. AN ENERGY CHAIN

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[12] H.T. Odum, "Ecosystem," p. 15.

The ratio of the energy input and output, or energy efficiency, is also called the energy quality factor. To help compare energies of different quality located in different parts of the energy chain on earth, we develop tables of energy equivalents, such as "solar equivalents" or "coal equivalents." This value and the ability to do work contribute to maximum power and thus contribute to the survival of a system.

Enthalpy is a measure of the quantity of available energy or possible work contained in a resource or system, without regard to its quality or energy form. For example, in terms of enthalpy, ". . . there is more energy in the form of low temperature heat in the Atlantic Ocean than in the form of oil in the Persian Gulf, but it is such low quality (high entropy) that it could not be used to do difficult kinds of work as oil could."[13]

4. Information, Spatial Concentration

From the following diagram, notice that the upgrading of energy quality is accompanied by the concentration of energy into smaller geometric space.[14] For example, going up the food chain concentrates higher quality energy into less calories for smaller populations (See Figure 5). The highest quality flows carry information because information can have the most diverse impact in a feedback interaction.

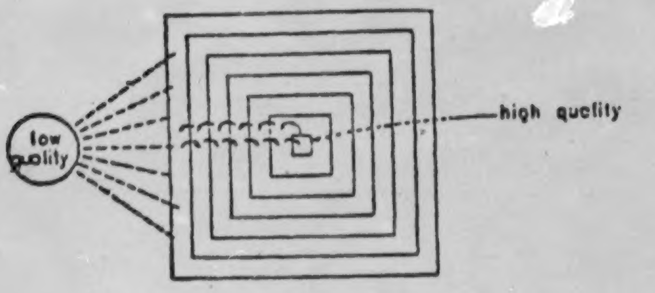

Figure 6. THE UPGRADING OF ENERGY QUALITY

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[13] Amory Lovins, Soft Energy Paths: Toward a Durable Peace (Cambridge, MA: Ballinger Publ. Co., 1977), p. 224.

[14] H.T. Odum, "Ecosystem", p. 115.

Considerations of energy efficiency and energy quality are vital in questions of energy supply and demand. There is no exact definition of energy quality, because its nature is relative to different energy resources. However, it can be described for any particular resource in terms of its enthalpy. Also, as energy is used to do work, it increases in entropy. To be useful, energy must be in a very orderly state (high enthalpy), such as that concentrated in a coherent flow of electrons (electricity), or in a lump of coal. If it exists in a dilute, random state, such as diffuse sunlight or low-temperature heat, little work can be obtained from it.[15]

This transformation of energy from a high enthalpy (low entropy) state to a high entropy (low enthalpy) state can also be described as a change from high quality to low quality. Such a transformation, which occurs when energy does work, and its reverse, which occurs as energy is upgraded in an energy delivery system, are governed by the principles of thermodynamics and energetics.

In relation to energy delivery systems, we can restate the two Laws of Thermodynamics as follows:

(1) The energy entering a system must be accounted for either as being stored or as flowing out; and,

(2) In all processes (or delivery stages), some of the energy loses its ability to do work and is degraded in quality.

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[15] Odum and Odum, Energy Basis for Man and Nature, 1976.

D. THE MAXIMUM POWER PRINCIPLE

As they go through their succession of dynamic patterns, ecological systems increase their degree of orderliness, develop better cycles, improve their control mechanisms, and form patterns that increase their productivity and consumer energy flows. Order and disorder are coupled: in order to achieve maximum power, a system requires some of each.

In addition to those principles of energetics outlined by Odum, there is another principle that is often referred to as the "third law of thermodynamics": The Maximum Power Principle. It is an explanation of why certain systems survive over others.[16] This principle says that the more lasting and more probable dynamic patterns of energy flow or power (including the patterns of living systems and civilizations) tend to transform and restore the greatest amount of potential energy at the fastest possible rate. For each step in the function of a system, this requires that up to 50 percent of the flow from potential energy storages tends to be expanded into the pool of energy dispersion and at least 50 percent is transformed into a new storage of energy available for a future process--one of higher quality.

The application of this principle to new energy or social systems developing in an environment of abundant resources generates competition between rival systems or subsystems to capture the most energy. The application of this principle to mature energy or social systems that are in "steady state," or in balance with the resources of their environment, generates cooperation. An example of this is inter-regional trade between an agricultural area and a manufacturing area in an industrial society.

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[16] A.J. Lotka, a biologist, wrote about a maximum power principle in an attempt to describe evolution in terms of energy. See A.J. Lotka, "Contributions to the Energetics of Evolution," Proceedings of the National Academy of Science, vol. 8 (1922).

When we talk about "surviving systems," we are not attributing conscious activities to vague collections of interacting entities. A surviving system is simply a system that exists in a certain space at a certain time, representing the particular configuration of system elements that has evolved in that location. For example, hardwood forests now stand in the mountains of New England, where coniferous forests once grew. The present system, having developed over time, has survived over the previous one.

Another example is the society residing in Albuquerque. At one time, the area was inhabited by different Native American tribal groups; now it is a predominately white industrial society. Because the white society had control of more energy and used it more effectively, it replaced the former society and, thus, survives.

In an evolutionary, ecological perspective such as this, energy is considered to be the prime motivating factor, and is therefore the final limiting factor. As such, moral values are not at issue; warfare is considered only as an expenditure of high-quality energy.

Surviving systems, i.e., those that exist by virtue of their success relative to other possible systems, exhibit the ability to develop more power inflow and to use energy most effectively to meet the needs of survival.[17] Such systems can:

(1) develop storages of high-quality energy as a buffer against energy shortages due to changes in the environment;

(2) use such storages to increase energy flow by investing the high-quality energy in the upgrading of available low-quality energy;

(3) recycle materials as needed;

(4) use stored high-quality energy to organize control mechanisms that keep the system stable and adaptable;

(5) establish exchanges with other systems for special energy needs.

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[17] Odum and Odum, Energy Basis for Man and Nature, 1976, Chapter 3.

E. NET ENERGY ANALYSIS

Energy production is one of many economic activities in our society. The motive for producing energy is simple enough: if it can be sold for more than it costs to produce, then it is a profitable enterprise. In economic terms, we can say that if the revenue a producer gets from selling energy is greater than his or her cost of production, then a net profit is earned. If the producer could not get a high enough price and had to sell below cost, then the operation produces a net loss. These economic concepts are easy enough to understand. Total revenues are the gross profit, and costs are subtracted to find the net profit.

Energy production has been economically motivated in our society for a long period of time, during which energy has been cheap to produce. Economic profits alone have been a sufficient incentive to stimulate energy sales, and the conveniences based on cheap energy have caused consumption of energy resources to grow at an ever increasing rate. However, we are now entering a period in which energy is not so cheap, and our energy-dependent lifestyle makes energy a very desirable commodity.[18] We are faced with a period where energy must be produced to maintain our lifestyle, whether the large economic profits persist or not. The cost of producing energy is rising because we have used up the greater part of our cheap, abundant resources. It now takes more money and more energy to extract energy from the environment and make it available for use.

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[18] C.E. Clark and D.C. Varisco, "Net Energy in Oil Shale," (Los Angeles: Atlantic Richfield Co., 1975).

In light of this situation, new criteria have arisen for analyzing the feasibility of new energy production processes. Since a greater part of society's wealth must be spent on energy, society as a whole must be more "profit" conscious. While one producer may be able to sell energy profitably at a high price, society may not benefit from the production of that energy.[19,20] From this concern over society's energy-profit, a new field of analysis has developed in which the net gain in energy associated with new energy production is considered. The name given to this school of thought is net energy analysis.[21]

Just as an energy producing project can be analyzed for its economic profitability, it can also be analyzed for its energy profitability. Net energy analysis is an accounting technique that looks at the energy resulting from a particular chain of energy production activities, and compares the results to the total amount of energy used to drive that chain of activity. When energy output is compared to total energy costs, we can determine the net energy profit of the particular gross energy production.[22,23,24]

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[19] David A. Huttner, "Net Energy Analysis: An Economic Assessment," Science, vol. 192: 101, April 9, 1976.

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[21] Martha Gilliland, "Energy Analysis and Public Policy," Science, vol. 189: 1051, September 26, 1975.

[22] Ibid.

[23] Odum and Odum, Energy Basis for Man and Nature, 1976.

[24] Clark W. Bullard, III, "Energy Costs and Benefits," Energy Systems and Policy, vol. 1, no. 4, 1976.

This way of viewing energy production systems is fairly new because energy production has traditionally been quite energy-profitable. For example, when oil is used to do work for society, it goes through several processing stages. We can call this series of stages, from raw resource to final end use, an energy delivery system. Briefly, an oil deposit is located, and oil is pumped out of the ground. The oil is shipped to a refinery for upgrading, then sent to various consumption sites such as gasoline stations, home fuel-oil heaters, and oil-fired electrical plants. In the case of electric power, there are several more steps through which the energy passes before it is finally available to do the work.

We can compare two energy delivery systems by comparing their net energy profit. Gross energy output minus total energy costs equals net energy profit.

Each step in this oil-based energy delivery system uses some energy. It takes energy to drive the pumps, run the tanker cars, operate the refinery, etc. But these energy costs have been very low in the past, so low that the energy cost of oil at two dollars per barrel was only about 1/30 of the total energy produced by the system.[25] This produced such a high energy profit that there was no reason to think further about it. As our oil resources have been used up, the net energy profit has begun to decrease and has therefore begun to attract attention.

To show how net energy analysis is useful for comparing alternative energy resources and energy delivery systems, we can consider nuclear powered electricity. Nuclear power has been promoted on the basis of its effectively "limitless" resource base. World reserves of nuclear fuels and the potential efficiency of their use in nuclear reactors are such that this energy delivery system was expected to provide us with cheap energy for centuries to come. Recent net energy analyses of the nuclear-electric delivery system susggest otherwise, however.

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[25] Gilliland, "Energy Analysis."

Nuclear fuels contain energy in a very concentrated form. In order to dilute this energy to a useful state, many complex processing steps are required. A great deal of effort must be expended in order to maintain environmentally clean operations, since nuclear materials are very hazardous to health and safety. Reactor temperatures are extremely high, and complex expensive machinery is required to manage reactor operations. All of these activities require energy for building and operating machinery, training personnel, transportation, etc. When all of the costs are totalled and compared to the gross energy produced from nuclear fuel, the net energy profit is much lower than it is for oil; the equivalent of about $\frac{1}{2.7}$ of the energy from one reactor is used to build, fuel, and maintain it.

Since different forms of energy are typically measured in different units, such as barrels of oil, cords of wood, kilowatts of electricity, we need some way to mix energy "apples and oranges" into common units. There are two ways to do this.

The first way is to eliminate units altogether by defining and comparing ratios. The Second Law provides a basis for measuring energy performance by describing the energy efficiency of the link between energy resources (or input), and the physical production (or output), of a system. Barry Commoner calls this the "Second Law Efficiency."[26] This efficiency can be expressed as a ratio that shows us what percent of the energy in a fuel is available to us after the fuel is converted to work:

$$\text{EFFICIENCY} = \frac{\text{Useful work or energy output}}{\text{energy input}}$$

Traditionally, efficiencies have been calculated for work-producing machinery such as cars, electrical heaters, light bulbs, etc. For example, an electrical power plant fueled by oil, gas, or coal has an efficiency of about 33% because it takes three units of fuel energy to produce one unit of electricity.[27]

$$\frac{\text{energy output}}{\text{energy input}} = \frac{1 \text{ unit}}{3 \text{ units}} = 33\%$$

Another way to compare energy in different forms is to consider the quality of energy in a particular form. Energy quality, as defined earlier in this section, is a measure of the ability of an energy form to do work. Electricity has a higher energy quality than does wood because there are many more tasks that can be done with electricity. In the same way, wood has a higher energy quality than does sunlight. We can burn wood to heat a house, but we need to collect and concentrate sunlight before it can provide heat for a house.

Energy has traditionally been measured in terms of its heat content. A common unit of measure is the calorie, which is the amount of heat energy required to raise the temperature of one milliliter of water one degree centigrade. It is important to know that all calories are not equivalent in quality. A calorie of dispersed heat cannot do work; a calorie of sunlight can do work if it is collected; a calorie of coal is already highly concentrated and can do a great deal of useful work. Each of these energy forms has different qualities.

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[26] Commoner, Poverty of Power, p. 177.

[27] Steinhart and Steinhart, Energy, Chapter 5.

In doing a net energy analysis, it is important to keep the quality of different energy forms in mind. For example, it may take barrels of oil, kilowatts of electricity, and calories of steam to operate an electrical production system. These must all be put in common terms and corrected for quality. One method proposed for this is to convert them to "coal equivalents"--the amount of work in a basic unit of coal, or "solar equivalents"--the amount of work in a particular unit of sunlight. The solar unit often used is the "solar constant"--1.36 kilowatts per square meter at the earth's outer atmosphere.[28]

In a net energy analysis, we are concerned with the overall efficiency of the entire energy delivery system. We can define a new efficiency ratio for the entire system--the energy yield ratio.[29,30]

$$\text{energy yield ratio} = \frac{\text{energy produced by the system}}{\text{energy costs of operating the system}}$$

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[28] Odum and Odum, Energy Basis for Man and Nature.

[29] Ibid.

[30] Gilliland, "Energy Analysis."

For the examples of oil and nuclear powered electricity, the yield ratios are approximately:

$$\text{yield ratio} = \frac{\text{yield}}{\text{costs}} \quad \begin{array}{l} \frac{3}{1} \text{ for oil ("old" oil at \$2/bbl)} \\ \frac{6}{1} \text{ for oil (Alaskan)} \\ \frac{2.4}{1} \text{ for nuclear} \end{array}$$

Since ratios of like measures have no units associated with them, we can compare different energy system alternatives by calculating their energy yield ratios. The higher the ratio, the more net energy is produced. A ratio of less than one signifies a net energy loss.

Productivity is the same ratio, usually expressed as a unit of output per unit of input, where the two types of units are not the same. This ratio is often used to describe energy/economic relationships.

$$\text{PRODUCTIVITY} = \frac{\text{energy produced by the system (in kilowatt-hours)}}{\text{energy costs to the system (in dollars)}}$$

We have used the principles of energetics as important organizing concepts in analyzing a system from an energy-flow perspective. Such a viewpoint, since it is a fairly new way to look at the world, can be a bit confusing at first. There are a couple of conventions used in net energy analysis that will help to make the technique more understandable and will identify the areas that have been criticized.

One problem that is not unique to net energy analysis, but is generic to all forms of systems analysis, is the definition of a system. Most people have an intuitive feeling of what a system is, and a simple definition is that it is a collection of interconnected elements. From there, we can define different types of systems in more rigorous terms. In net energy analysis we are concerned primarily with dynamic systems (they change with time) which can be described in terms of the energy flowing through them. Some are self-maintaining, and some are subsidized by other systems.

In doing a systems analysis, there is a more specific problem of definition. In order to analyze a system, we must state exactly what is included in it. Even though all things are interconnected in some way, clearly we must exclude some parts of the universe in order to focus on one particular part. Therefore, we must define a system boundary around the system of interest. For example, shall we analyze the world, the U.S., one state, one town, or just a neighborhood? Any of these can be defined as a system.

The concept of a system boundary is important because it can determine the results of an analysis. For example, one net energy study of a nuclear power plant might show that an average reactor is a net energy producer. After X years of operation, it produces as much energy as was consumed in construction of the plant (it has a payback period of X years), and then produces an energy-profit. When the system boundary is expanded, however, to include all reactors in the U.S. and the uranium processing activities supporting them, the conclusion about nuclear power is much different. An analysis of this expanded system suggests that the system will never produce more energy than it will take to build it. Such conflicting conclusions can often result from analyses using two different perspectives, or from different choices of the system boundary.

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Another related concept is the choice of what to include within the system boundary, from those things that appear to be included. For example, if the system boundary coincides with a natural region such as a river basin, is it necessary to represent all processes in the area, or can some be ignored for purposes of simplicity? In other words, what value should be assigned to each element in the system and the interactions between them? Clearly, a net energy analysis of the river basin does not need to include an exact representation of the feeding habits of one fish in the river.

One point of uncertainty and conflict in the field of net energy analysis is the assigning of values to system elements, and the choice of which elements to include. How do you account for all of the energy inputs to an energy delivery system? Clearly, there is an input of energy spent to build an oil refinery--diesel fuel for the trucks, electricity for lights, etc. These are direct energy costs, easily measured inputs to the system. But there are also indirect energy costs such as gasoline for workers' cars, energy used to produce the steel used in pipes, and the energy cost of training people to work in the refinery. Problems arise in trying to determine these energy costs. Conflicting results can occur if two similar analyses assign different values to an important energy input, such as human labor or special education.

Net energy analysis as a specialized research technique has many unresolved details at this point in time, but the idea has resulted in the development of some basic concepts that offer an important perspective on energy problems. The basic idea that some energy production processes produce more net energy than others is important to keep in mind. In the U.S. and in the world, we are rapidly depleting the stocks of high-quality energy that existed in the fossil fuel reserves. At the same time, the demand for energy is ever-increasing. The combination of these two trends will result in an increase in gross energy production with a less rapid increase, and eventually a decline, in net energy production. To avoid such a fate, a new emphasis must be placed on energy quality, appropriate energy use, conservation, and new designs for energy delivery systems.[31]

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[31] Lovins, Soft Energy Paths.

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F. NET ENERGY ANALYSIS: A BIBLIOGRAPHICAL ESSAY

The concept of "net energy" and methods of net energy analysis have gained widespread popularity in recent years, along with discussions of the "energy crisis" and energy conservation. The basic ideas of net energy, those of technical and process efficiency for energy production systems, have been common elements in the fields of physics and engineering for many years. Net energy analyses have expanded the application of these ideas to areas outside the traditional boundaries of technical analysis.

Net energy analysis, as a consistent and accepted technique, is still in the stage of being developed and promoted by several different advocates. There are areas of disagreement between different proponents, and several points of criticism from outsiders. While there is no one specific accepted methodology, the general idea of net energy analysis has received positive recognition as an input to energy policy decisions.

Net energy analysis gained official national recognition with the Non-Nuclear Energy Research and Development Act of 1974. One of the five governing principles for energy production technology evaluation listed in this act states that "the production of net energy by the proposed technology at the stage of commercial application shall be analyzed and considered in analyzing proposals."

Net energy analysis first gained visibility in 1974 and 1975 through the publication of articles concerning applications to specific energy technologies. Chapman and Mortimer (1975) applied net energy analysis to nuclear power stations. Clark and Varisco (1975) offered an application to oil shale, as did Penner (1975). Murray (1975) utilized net energy analysis in the State of Oregon energy study.[32]

This array of different applications is the visible result of the development of several schools of net energy analysis. The three most established schools are discussed here. These three have been most visible and most widely reviewed thus far. All three share basic concepts but differ in perspectives.

One school of net energy analysis has been developed by researchers led by Howard T. Odum at the University of Florida at Gainesville. Several examples of this highly developed method can be found in Gilliland (1975), Marshal (1972), and, and OERP (1975).

Odum's method is based on concepts derived from the observation of energy flows in ecological systems. Net energy calculations are a sub-unit of overall energy analysis. A basic step in the technique, and a point which attracts criticism, is the measurement of system elements in terms of energy units. Factors such as labor, raw materials, etc., have traditionally been measured in dollar terms and there is much discussion concerning the conversion factors between dollars and energy units. System elements are further valued according to the quality of the energy they utilize, thus translating all factors into a common energy denominator. With this method, non-economic externalities (pollution, wind, land, air, etc.) can be put in terms consistent with the traditional economic variables.

The Odum school emphasizes the importance of net energy analysis in public decision-making (Gilliland, 1975). In doing so, it takes a radical position in an argument between energy and economic analysts. Proponents of the Odum school offer net energy analysis as a replacement for economic analysis, rather than as a supplemental viewpoint. This position has received a great deal of criticism.

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[32] See Bibliography for full references cited in this essay.

In an important article, Gilliland (1975) proposes energy usage as an alternative unit of value measurement in the economy (in addition to traditional dollar measurement). Qualified support for this notion is found in an earlier article by Hannon (1974). Bullard (1976) emphasizes that energy usage can be considered to be the primary component of values, but it is not the only component. Gilliland's article was interpreted by many to be an argument for a new "energy theory of value," and thus caused a flurry of criticism from economists and energy analysts alike. The discussion can be found in a series of letters in Science (1976 and 1977). A major opponent of the "energy theory of value" is Huettner (1976).

A second, distinctly different school of energy analysis has arisen from an attempt to standardize techniques used by several independent analysts. Some degree of cohesion was reached at the workshop on energy analysis methodology held by the International Federation of Institutes for Advanced Study (IFIAS) in Sweden in 1974 (Slesser, 1977). The main distinction between this school and the school of Odum concerns the energy value assigned to the sun and to human labor. The Odum school attempts to assign energy values to both of these, while the IFIAS school regards the sun as a free good and the energy costs of labor to be accounted for in terms of energy used for human life support systems. This method allows the comparison of net energy studies with parallel economic analysis, but proponents emphasize that these two points of view are necessarily separate ways to study a system. A major spokesman for the IFIAS school is Slesser (1977).

A third method of net energy analysis was proposed by Bullard (1976). In an article for Energy Systems and Policy, Bullard presents methods for quantifying net energy impacts of both individual energy facilities as well as entire energy-economic systems. This method was developed at the Center for Advanced Computation at the University of Illinois, Urbana.

Bullard's method is derived from standard "input-output analysis," an economic tool developed by Leontief (1922). The basic concept is that all processes in the economy consume some energy. If the direct and indirect energy requirements of production are known, the energy sector of the economy can be analyzed for its net energy output. The entire economy is included in the system being analyzed, and this allows one to consider gross energy questions as well. Bullard points out that gross energy is a more appropriate measure in some instances.

G. ENERGY QUALITY: A BIBLIOGRAPHICAL ESSAY

If energy is delivered to your home in the form of electricity, you can watch television, light up the workroom, and keep the house warm. If energy in the form of coal is delivered by a dusty truck each morning, the house could still be heated but the lights and television would have to go. Why is it that we cannot use coal to run electrical conveniences? Because coal contains energy of a lower quality than electricity. Energy quality is a measure of the available work contained in an energy form. In order to light your house with coal, the energy in it must be upgraded by converting it to electricity at an electrical power station.

Energy comes in many forms, each containing different qualities of energy. For example, there is an abundance of low-grade energy contained in low-temperature heat stored in the oceans, or in the sunlight that strikes the earth daily. Such low-grade energy must be collected and concentrated by processes that improve its quality before it can be put to use where higher grade energy is needed. The quality of an energy form refers to the diversity of different purposes for which it can be used. (Gilliland, 1975; Loose, 1976)

Energy quality has become an important concept in the discussion of energy conservation. When energy quality is considered, it becomes apparent that we can save a lot of energy by making sure that different energy forms are used for the right purposes, and that the quality of an energy is matched to the quality of work desired. (Lovins, 1976)

For example, if it takes fifty pounds of coal to heat your house for a day, it would take about one hundred and fifty pounds of coal to produce enough electricity to heat your house for the same day. The extra hundred pounds of coal are consumed in increasing the quality of the other fifty pounds of coal by converting it into the electrical energy delivered (Odum and Odum, 1976). Instead of gaining the low-quality energy in fifty pounds of coal, we gain the high-quality energy of electricity and discharge a large quantity of waste heat that has a lower quality energy than the coal contained.

Our consumption of energy will be more efficient if we match the quality of fuel with the quality of work desired. We should avoid mismatches, such as burning uranium at temperatures of thousands of degrees in a nuclear reactor to heat a house to 70°. (Georgia Conservancy, 1976) In the U.S. we presently meet 13 percent of our energy needs with electricity, while only 8 percent of our energy needs require the high-quality energy contained in electricity. (Lovins, 1976) At the same time, we are planning the construction of new electrical plants to produce 20 percent to 40 percent of our needs by the year 2000. If we were to produce only the electricity we really need and avoid using electricity in applications that can operate on low-quality energy, we would save all the energy used to upgrade energy into the form of electricity. The energy saved (or fuel resources not consumed) by carefully matching energy sources to work quality constitutes the largest and cheapest energy resource we have. (Georgia Conservancy, 1976)

What determines the quality of an energy form? It depends partly on the nature of the fuel and the uses to which it is put. There is no rigorous definition of "energy quality," but it is related to some well-known physical concepts. Pure fuel resources (coal, oil, gas, uranium, etc.) contain a measurable "free-energy" which can be converted to work. This "free energy" is approximately equal to the "heat content" or "enthalpy" of the fuel, a measure of the work that can be derived from it. (Bullard, 1976)

A high-quality energy from this source has a high enthalpy and, at the same time, a low entropy. (Odum, 1976) The energy in coal, for example, is concentrated to the point where work can be easily obtained. Sunlight has a lower enthalpy because it is not as concentrated, but is diffused or diluted. Sunlight has a higher entropy, or disorderliness, than coal. Disorderly energy is more difficult to harness; it has less available work.

Any improvement in energy quality, by the upgrading processes of energy production in a system, produces a simultaneous decrease in entropy. When energy is used to do work, its enthalpy is spent and its entropy increases.

Energy quality is a more complex idea than enthalpy. An energy form contains an amount of "potential energy" available for work. (Odum and Odum, 1976) But the quality of the energy depends on how that potential energy is released. Water, for example, has energy associated with it as it sits above a hydroelectric plant. The same water has a different quality of energy stored as heat, and a much higher quality energy stored as combined hydrogen. The quality of energy derived from it depends on how the water is used.

As energy is processed through the steps of an energy delivery system--the series of transformations from fuel resources to end use--it gains quality up to the point of end use, when work is done and low-quality waste heat is discarded. For example, as coal is burned to produce steam to then generate electricity, the energy in the coal is transformed into the higher quality energy in electricity. From studies of ecology, we know that energy increases in quality as it passes through any system. (Odum and Odum, 1976) For example, dispersed energy in sunlight is concentrated by plants and further by humans who eat the plants.

Each step in the improvement of energy quality involves conversion of energy to a different form. There are losses of energy associated with conversions, due to the rejection of energy with a quality too low to be useful to the system (Steinhart and Steinhart, 1974). When fossil fuels are burned to produce electricity, about 70 percent of the energy is discarded as low-grade waste heat contained in water used to cool the steam-producing machinery. This low-grade heat is not useful for electricity production, but could be used for space heating of nearby buildings, which requires lower temperatures (lower quality energy) than does electricity production (Business Week, 1977). Such multiple-use schemes are one important aspect of future energy conservation measures. Another obvious aspect is the elimination of energy conversion losses altogether by matching fuel usage to end use requirements, therefore eliminating many cases of unnecessary energy upgrading. (Lovins, 1977)

Energy quality is an important concept for energy resource planning. By using only that type of energy required for a task, we can avoid much of the energy waste that has become common during the days of cheap and abundant fossil fuels.

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ENERGY/
RESOURCE
DELIVERY
SYSTEMS

A. INTRODUCTION

Many sources of energy are available for our use--sources such as fossil fuels, nuclear fuels, and sunlight. We harness these energy sources to do work for us: to heat houses, propel cars, light streets, and to do other chores that we cannot, or do not want to do ourselves. We cannot, however, get much work out of fuels in their raw forms. For example, we cannot warm up a room by throwing a piece of coal on the floor. In order to get work out of an energy source, we must process it into a usable form and then transform it into work through some mechanical, chemical, or electrical process.

The concept of an energy resource delivery system is not new.[1] In holistic environmental education, however, special consideration must be given to ensure that the whole delivery system--from raw resource to end use--is included in the analysis. Historically, different disciplines have looked at segments or phases of the system individually, from a cost-effective viewpoint. Simply putting several of these studies together does not suffice as a holistic analysis. Energy/resource delivery systems, as discussed here, are defined in Transition, a publication of the Office of Energy Research and Planning, Office of the Governor, State of Oregon. The studies in Transition utilize the energy/resource delivery system as a framework for determining the net energy efficiency of fourteen energy delivery systems that produce electricity.

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[1] Office of Energy Research and Planning, Office of the Governor, State of Oregon, Transition (Portland: Prometheus Unbound, Speciality Books), 1976.

B. ENERGY DELIVERY SYSTEMS

The series of processes needed to change a raw fuel into useful work is called an energy delivery system. Many different energy delivery systems are in use in our society, allowing different energy sources to be put to different uses. For example, the energy delivery system that allows you to cook on a gas stove is much different from the energy delivery system that provides you with electricity for your television, which in turn may be quite different from the energy delivery system that allows your cousin in a different state to run her television. There is also the energy delivery system of the natural systems that can, for example, provide food to fuel our bodies, or wind to pump water, etc.

One common energy delivery system results in the use of electricity through the burning of oil. The oil is located, pumped from the ground, delivered to a refinery, made into boiler fuel, delivered to a power plant, and burned to change water to steam. The steam turns a turbine which generates electricity. The electricity is transmitted by wires to your house, and is finally put to use running different appliances. There are, of course, many more details to the system, but the central flow of energy is easy enough to trace.

To provide a framework for comparison of different energy resource delivery systems, we can define eight basic stages of the energy delivery process, from initial collection of primary resource to final end use. These stages may not apply to all delivery systems, and some systems may exhibit more than one process in each stage. It is important, however, to see how seemingly different processes in the environment can be described in similar terms, and how some energy systems may have advantages over others. These stages help to explain the general structure of a delivery system. (See Figure 1.)

STAGE	SAMPLE ENERGY DELIVERY SYSTEMS	
	OIL TO ELECTRICITY	WHEAT TO BREAD
1. EXPLORATION: siting of resource deposits, basic research and development of exploratory techniques, machinery	Geologic exploration for oil	Agricultural chemist's search
2. EXTRACTION: removing the resource, machinery and site equipment, materials, operating agencies, maintenance over the life of the site	Tapping oil well	Harvesting wheat
3. TRANSPORT I: transportation mechanisms and operating energy necessary to carry the resource to the next facility	Shipment of crude oil	Trucking of grain
4. PROCESSING: energy to run machinery, construction of the facility, its maintenance and operating energies	Processing of crude oil	Grinding of grain
5. TRANSPORT II: transportation systems and the operating energies required to move the resource to the conversion plant	Shipment of partially refined oil to a regional refinery	Trucking of flour to baker
6. CONVERSION: plant construction, materials and maintenance	Transformation of oil into electricity	Transformation of dough into bread
7. DISTRIBUTION: energy costs, equipment, storage facilities and networks to move the converted product from final facility to point of consumption	Sale of electricity to a household	Sale of bread at grocery store
8. END USE: Input to the "basic human needs" system	Operate electric toaster	Eat the bread

Figure 1. EIGHT BASIC STAGES OF THE ENERGY RESOURCE DELIVERY PROCESS

C. TYPES OF ENERGY RESOURCES

Some resources exist in a natural state and some are by-products of other activities in our society. The former are primary energy resources. We can define two categories of primary energy resources:

- Non-Renewable: a quantity of finite reserves that are made available to society as a function of available technology and capital investment.[2]
- Renewable: infinite reserves are available at specific rates to humanity depending upon specific locale; their availability as an energy resource is also a function of available technology and capital investment.

The following chart lists these renewable and non-renewable primary energy resources.

NON-RENEWABLE PRIMARY ENERGY RESOURCES	RENEWABLE PRIMARY ENERGY RESOURCES	
Petroleum	Solar	Radiant Solar Heat Photovoltaic Conversion
	Wind	
Natural Gas	Hydrological	Fresh Water Hydroelectric
Coal	Oceanographic	Tidal Temperature Gradient
Fissionable Materials	Geothermal	Steam Heat
	Life Forms	Human Photosynthesis Forests
	Recyclable Waste	

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[2] Amory Lovins, "Energy Strategy: The Road Not Taken?" Foreign Affairs, vol. 55, no. 1 (October 1976), pp. 65-96.

The important distinction between these two types of resources is that non-renewable resources exist in the earth in limited quantities that could conceivably be used up some day, while renewable resources will be available as long as the total earth ecosystem is functioning. There are some other important distinctions as well. Non-renewable resources exist as concentrated forms of energy which have historically been fairly easy to collect and use, while renewable resources tend to be diluted and require a great deal of effort to collect for use.

The quantities of non-renewable resources available to us have been limited only by the speed at which we can pump or dig them up, while renewable resources are available to us only as fast as they are processed by the natural system. For example, we cannot collect more sunlight in a day than falls on the surface of the earth.

Human society has relied on renewable resources through most of its evolution: for example, solar-based agriculture, wood heat, and coal-fired steam. But in recent history we have been rapidly depleting our supplies of cheap non-renewable resources such as fossil fuels. The "energy crisis" we currently face is based upon the realization that cheap non-renewable energy resources will soon be gone and technologies must shift toward the use of renewable energy resources.[3,4]

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[3] Howard T. Odum and Elisabeth C. Odum, Energy Basis for Man and Nature (New York: McGraw-Hill Book Co.), 1976.

[4] U.S. House of Representatives, "Middle and Long-Term Energy Policies and Alternatives," serial no. 94-63 (March 25, 1976).

It is also possible to tap "waste" energy from activities in society that have a different primary purpose. These secondary or tertiary energy sources are recycled energies from processes driven by a primary energy source. For example, the steam used to generate electricity in a power plant is often discarded as "waste" heat. This steam, though not hot enough to drive a turbine for a second time, is still hot enough to heat nearby buildings. So, the "waste" from one activity can be used as a source for another. Other examples of this process of cogeneration are the use of steam produced for other industrial activities to heat buildings, or the burning of municipal waste for power generation.[5] Such cogenerating systems improve the overall efficiency of an energy delivery system by making use of energy that would otherwise be discarded.[6,7]

As energy moves through an energy delivery system, changing in form from basic resource to useful work, there is an increase in the quality per unit of energy available. Each step in the system improves the quality or possible diversity of energy use.[8,9]

For example, mined coal could be burned to heat your house or it could be burned to produce electricity to heat your house as well as lighting it and running electrical appliances. The energy in electricity has a higher quality than the energy in mined coal because it can do more and different kinds of work. The complexity of an energy delivery system depends on the final end use required.

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[5] "Saving Energy the Cogeneration Way," Business Week (June 6, 1977).

[6] Lovins, Foreign Affairs, p. 65.

[7] Amory Lovins, Soft Energy Paths: Toward a Durable Peace (Cambridge, MA: Ballinger Publishing Co.), 1977.

[8] Martha Gilliland, "Energy Analysis and Public Policy," Science, vol. 189 (Sept. 26, 1975):1051.

[9] K.D. Loose, "Six Energy System Concepts," Paper presented at the Eighth Annual Symposium on Systems and Education, Far West Laboratory for Educational Research and Development, San Francisco, CA (1976).

Each stage in the energy delivery system does work to upgrade the energy passing through it.[10] In transforming sunlight into the stored energy contained in wood, a tree grows. Growth is powered by the sun. Therefore, the tree uses energy to upgrade energy. Some sunlight energy is used to power the process of concentrating the rest of the sunlight energy in the wood.

The same principle holds for each step in any energy delivery system: some energy is needed to upgrade energy. The energy used to do the upgrading, since it can do its work only once, is then discarded as unusable waste heat, unless it can be used as a secondary energy source for some lower quality work. This means that there are two main types of energy end use:[11,12]

- Direct Use: burning of gasoline, operation of electrical appliances, consumption of petrochemical feedstocks.
- Indirect Use: includes all the other energy forms that are required to make the direct energy available for use. These include the energy necessary for the construction and maintenance steps in the energy delivery system.

In the case of certain nuclear reactors, it appears that the energy "cost"--the energy required to build and operate the nuclear energy delivery system--is greater than the energy produced by the system. This is because energy is so concentrated in nuclear fuels, it takes a great deal of energy to dilute it to a usable form. Thus, the system uses more energy than it produces; it is a net energy consumer rather than a net energy producer. Other energy sources are needed to subsidize the nuclear system. This is an example of how a net energy analysis of the entire energy delivery system (i.e., a study to determine whether the system produces a net gain or net loss of energy) can shed a new light on possible energy sources.

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[10] Odum and Odum, Energy Basis, Chapter 3.

[11] Howard T. Odum, Environment, Power and Society (New York: Wiley-Interscience), 1976.

[12] Clark W. Bullard, III, "Energy Costs and Benefits," Energy Systems and Policy, vol. 1, no. 4, (1976).

Energy flows out of an energy delivery system at the point of end use and also through losses occurring at different stages.[13] There are three main types of energy loss during processing and delivery. Some energy is lost to degradation, a leakage of energy potency during storage, such as occurs with long-unused gasoline, or when a battery loses its charge. There is also some physical loss, such as oil spilled in tanker accidents, or contaminated fuels such as low grade ore or coal with a very high sulfur content. Some energy is also lost to internal use at the various processing stages, such as using some of the produced electricity to light the power plant.

Such losses are also energy "costs" in the system, but should not be confused with the energy costs due to upgrading energy (conversion losses), which occur when high quality energy is fed into the system from another energy system or is fed back further along in the same system to do the work of upgrading energy in the main flow.[14] These upgrading costs are measured by the low grade energy being discarded from the system as its work ability is consumed.[15]

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[13] Transition, 1976.

[14] Carol E. Steinhart and John Steinhart, Energy: Sources, Use and Role in Human Affairs (North Scituate, MA: Duxbury Press), 1974.

By considering the whole delivery system associated with an energy resource and its desired end uses, we can compare the amount of energy produced with the energy costs of producing it. Such a net energy analysis can indicate the success of the total system in comparison with other systems. A net energy consumer system may be unacceptable to society unless it produces a very high quality energy that has an important special use, and there is adequate energy from other net energy producing systems to subsidize it.[16,17]

The examination of energy delivery systems allows us to consider another important concept, that of matching energy quality to the quality of work needed. As stated previously, energy delivery systems consist of stages for upgrading the quality of energy, and each stage has energy costs associated with it. Therefore, we can save a lot of energy by building delivery systems, or substituting other delivery systems, to produce only the quality of energy needed for the task.[18,19]

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[15] For a discussion of these concepts, see Odum and Odum, Energy Basis.

[16] Bullard, "Energy Costs and Benefits."

[17] Keith S. Krause, "The Application of Physical, Chemical, and Biological Laws of Energy Transfer as an Economic Evolution Standard," Congressional Record, U.S. Senate (July 9, 1977).

[18] Georgia Conservancy, "Wolfcreek Statement: Toward a Sustainable Energy Society," Atlanta, GA (1976).

[19] Lovins, Soft Energy Paths.

To illustrate this point, consider a natural gas-to-electricity delivery system being used to warm a house in which the Thanksgiving turkey is being carved by an electric knife. Electricity is an especially high-quality form of energy and has many important, unique uses. But a house heated directly by natural gas consumes only one-fourth as much of the primary resource as a house heated by electricity, since it takes about four units of lower grade gas to produce one unit of higher grade electricity. (Three units are consumed in the work required to upgrade the rest.) Space heating can be done with energy of a lower quality than electricity.

At the same time, a turkey can be carved by a non-electric knife powered by energy delivered from a sunlight-food-human system. The energy stored in human muscle tissue is of a much lower quality than electricity, but is entirely adequate to operate a knife. If the electric knife is used, energy is being expended to upgrade a resource to electricity, which is not really required for the task. Such quality mismatching results in a great waste of energy.[20]

By looking at energy production in terms of whole energy delivery systems, we can gain a better understanding of the energy costs associated with such processes. This allows us to identify points in the system where energy losses can be reduced by matching desired tasks to energy forms of the appropriate quality. It also allows us to compare alternative energy sources on the basis of their net energy contribution to society.

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[20] For a discussion of the importance of viewing energy systems in this way, see Lovins, Soft Energy Paths.

It is important that we examine energy resource delivery and use in terms of a systemic approach such as the framework outlined above. However, there are many more considerations to the problems of energy delivery strategies than simply the availability of resources and technical efficiency. To take a comprehensive look at a delivery system, it is necessary to examine the actual steps in delivery in terms of environmental impact as well as in terms of energetic considerations and efficiency. It is also important to examine the effects of social, political, and economic structure on delivery--and vice versa.

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FORECASTING
PLANNING
AND
POLICY
FORMATION

A. INTRODUCTION

One of the classical distinctions between humans and other life forms on our planet is that humans can anticipate the future and plan ahead. Whether you can accept this as a distinguishing human trait or not, it is certainly an observable characteristic of the human creature and human societies. Be it a concern for a rainy tomorrow or a new age of space travel, people are constantly looking toward the future, trying to make some guess about or plan for its composition.

This speculation about the future is actually a social institution. A person is constantly being persuaded to plan for his or her career, family, or retirement. In most human societies, the individual has a plan for the future, whether that plan is supplied by the person or by external conditions. Whole societies have their plans as well. Expectations or goals for the future are a vital component in social decision-making.

We tend to associate prophecy and prediction with less "civilized" cultures. Although wizards and soothsayers may be able to foretell the future, these are not common professions in our society. But our society is no different than any other when it comes to curiosity about the future; we have just dressed our soothsayers in technological clothes.

Over the past thirty years, many new methods of forecasting the future have been developed. These methods may be called scientific or technological, but none are notably more successful than "primitive" prediction methods. We have begun to look at the future in an analytical, logical way, rather than relying on the more intuitive, common-sense speculations of earlier days.

What is the purpose of forecasting? If you have a good idea of what the weather will be like tomorrow, you can plan your activities accordingly. Or if you want to have your house painted by the end of summer, you can think about the different things that must be done to reach that goal and plan out the required steps.

Forecasting is used for similar types of planning for society as a whole. Whether the planners are individuals, corporations, public utilities, or government agencies, the uses of forecasting are essentially the same. We make extrapolative forecasts to help us prepare for circumstances that are expected to occur, and we make normative forecasts that define a goal, in order to guide our activities toward attaining that goal.

Extrapolative forecasting is often used by public utilities. For example, a utility might forecast a future rate of regional population growth equal to the rate observed over the past ten years. If the population had doubled in the last decade, the forecast would show another doubling of population over the next ten years. If this forecast was the sole basis for the utility's planning, then the utility would probably decide to double their existing facilities over the next ten years in order to maintain the same level of service per person.

Normative forecasting was done by the aircraft industry when they decided to build the supersonic transport (SST). The goal was set to have a fleet of SST's by a certain date. Designing and testing began, and sales promotion was initiated to ensure that there would be a market for SST's when production began.

Forecasts are useful as one input to decision-making and policy formation. Decisions are individual choices made between alternatives visible at a moment in time. Policies are a set of rules formulated to guide decisions. For example, you might have a personal policy of always carrying an umbrella on days you think might be rainy. You will make actual decisions about taking the umbrella on each day, depending on how the weather looks.

It is important to keep in mind that forecasting is just one possible input to decision-making and policy-formation. This is especially important to remember in looking at the decision-making processes of government. Decisions or policies may appear to contradict seemingly reliable (or sophisticated) forecasts.

For example, you may leave your umbrella home on a very cloudy day because you are in a hurry to get out the door, or because your intuition tells you the clouds will blow away. A city council may approve a housing development because the construction industry is a strong interest group in favor of the project--even if the city sewage plant is expected to be inadequate for the projected population five years in the future. Many different factors may play a part in a decision-making process.

To help create an understanding of modern forecasting techniques, their purpose and success, we shall take a brief look at their historical development. Then we will look at the major forecasting methods currently in use and the differences between them. Finally, we will examine two major applications of forecasting and the controversies surrounding them.

B. A BRIEF HISTORY OF FORECASTING

Before the twentieth century, forecasting was primarily a metaphysical or philosophical pastime of a few individuals. Legends or historical accounts of the oracle of Delphi, Nostradamus, and Merlin come to mind. Methods included the use of crystal balls, tea leaves, dice, cards, etc., as well as the making of day-to-day predictions, based on folk traditions and careful observation of local natural phenomena.

Similar methods of prophecy and prediction still exist--e.g., The Farmer's Almanac, which has proven to be one of the most consistently successful predictors in the United States. But science has been a prime mover in our society, and most human activities have been given a scientific expression somewhere along the line. It was only natural for speculation about the future to become a scientific venture.

The earliest institutional use of technological forecasting occurred during World War II. As with many other technical innovations, scientific forecasting grew out of military activities. Along with the rapid development of new gadgets for warfare grew a concern for the assessment of the effects of that gadgetry. One side wanted to assess the full implications of the potential of the other side's machinery, as well as to assess the potential success of their own machinery under development.

This concern for assessing the impacts of certain technologies resulted in the establishment of the RAND Corporation shortly after World War II (Kauffman, 1976). RAND was a semi-private civilian corporation originally set up by the U. S. Air Force to make assessments of what could be expected from technologies under development.

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C. FORECASTING METHODS

A large number of methods for forecasting the future have been developed over the last thirty years; one author has identified over one hundred (Jantsch, 1967). Some general categories will be described here. Examples and references for each category are listed in the bibliography.

A few terms should be defined at the outset. We have chosen the word forecasting as the general term for all kinds of thinking about the future. Some people feel that a more general term of simply "futures thinking" or "futuristics" encompasses all activities that are concerned with the future (Boucher, 1977; Kauffman, 1976). Forecasting is a subset of futures thinking, as it is a particular type of thinking about the future. A forecast is a statement that, given certain conditions, the future will probably look a certain way. In contrast to this is prediction. A prediction is a statement that things will be a certain way.

Projection is closer in meaning to forecasting but tends to be a more positive statement that the future will be such if conditions are such and the world responds in certain ways. Extrapolation is simply a statement that the future will be an extension of the present with no big surprises.

These terms will become more clear as we look at some particular forecasting methods. The particular methods described here each have many subcategories and have been applied in many different ways. Also, some have been applied in different combinations. The general categories described here will, however, illustrate some of the basic differences between methods, the biases behind them, and the reasons why they often result in differing conclusions about the future.

1. Intuitive Forecasting

As a reference point, we should consider the non-rigorous activity of intuitive forecasting. This simply means the process of conjecturing about the future based on the way one perceives the world and the processes at work in it. You can say intuitively, for example, that the U.S. will still be operating ten years from today in basically the same configuration because it has been for a while and does not seem to be suffering from any great problems. Such intuitive forecasting is not likely to produce precise predictions of the future. A person isn't likely to have an intuitive feel for the exact population of his or her hometown ten years away, though some estimation can be made.

If several people combine their intuitive forecasts for the future and discuss them at length to produce a common forecast, they have produced a forecast by group consensus. Again, precision is not to be expected.

A method has been developed to add an element of rigor to the group consensus process and to add structure to intuitive forecasting. This method is known as the Delphi Technique and it draws on the knowledge of persons expert in the particular subject being forecast. These experts are independently asked to estimate values for certain variable quantities, such as oil production in 1980. The results are tallied, summarized, and returned to the participants. In this way, they can have an anonymous look at what their colleagues have estimated and, on the basis of this, are allowed to revise their own estimates. Successive rounds of inquiry follow in an attempt to reach a consensus among participants on the values of interest. Then a scenario is written on the basis of the combined results of the survey. The Delphi Technique was developed by Olaf Helmer and his associates at the Rand Corporation (Duncan, 1973).

2. Trend Extrapolation

The second forecasting technique is probably the most commonly used of all: trend extrapolation. The basic procedure involved is to collect data about the variables of interest, such as population growth or oil consumption, and to form a "data base." These data are plotted on a time-graph to create a picture of how the variable has changed over some period of history, called the "base-line." The longer the base-line, the more confidence one is likely to have in the "trend" that is revealed. The trend is the basic pattern or behavior shown by the variable. For example, if data are collected on oil consumption over the period 1950 to 1978, a definite pattern of growth or increasing oil consumption can be seen.

Using various sorts of mathematical techniques called "curve-fitting," the analyst tries to find an equation that produces a curve similar to the observed trend. Using the best equation, as determined by statistical testing, new values for the variable are then calculated for dates in the future. The result is a continuation, or extrapolation, of the historical curve, or trend, into that section of the graph which represents the future. The length of time into the future being forecast is called the "time horizon." Again, in the case of oil consumption, a trend extrapolation forecast would show continued consumption at an increasing rate.

Trend extrapolation has been used extensively with great success in areas such as short-term sales forecasting and public utility demand forecasting. There are some definite drawbacks to this method, however. Trend extrapolation assumes, essentially, that the future will be like the past; that controlling forces operating in the past will continue to control activities in the future. Consequently, the method is fine for short-term forecasts, but is not as useful for long-term forecasts. Using trend extrapolation there is no way to anticipate changes in the future, such as finite quantities of resources. In the oil consumption example, trend extrapolation forecasts would be unable to anticipate events such as the 1973 oil embargo, or the inevitable decrease in oil consumption as oil reserves are finally exhausted. Some work has been done to attempt to make up for these deficiencies in the method (see Boucher, 1977).

3. Scenarios

Next on our list of forecasting techniques is the rather loosely defined category of scenario writing. A scenario is a description of one possible future; either the state of some aspect of the world at a specified future date or a sequence of events or activities leading to a certain state. Scenarios can be written by individuals or by whole research teams.

Scenario writing typically relies on intuitive speculation as well as on mathematical calculations, so this method of forecasting is not limited by the mathematical restrictions that constrain trend extrapolation. Scenario writing also avoids the measurement and variable definition problems associated with the more rigorous forecasting techniques--techniques that often apply mathematical approaches to typically non-mathematical aspects of life.

Scenario writing often serves as a structure for organizing a multi-method forecasting effort and a means of specifying alternative possible futures. A good example of this is the Ford Foundation energy study, A Time to Choose (Ford Foundation, 1974.) The presentation of different possible futures can be used to contrast the ultimate consequences of choices made now. An execllent example of this is "Energy Strategy: The Road Not Taken?" by Amory Lovins, in which two distinctly different futures are described for the U.S., depending on energy choices made today (Lovins, 1976). Another example which exhibits a more philosophical and less mathematical treatment of future possibilities is Buckminster Fuller's Utopia or Oblivion (Fuller, 1969). A good example of a more predictive approach, and a description of how the world will be rather than the process of its development, is Kahn and Warner's The Year 2000 (Kahn, 1967) and The Next 200 years (Kahn, 1976).

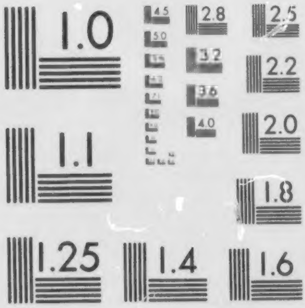
4. Cross Impact Analysis

A more formal method of forecasting now in use is cross-impact analysis. This method, also developed by Olaf Helmer, in conjunction with Theodore J. Gordon, is based on the realization that simple forecasting, such as trend extrapolation or Delphi studies, does not take into consideration the possible interaction of forecasted elements (Hetman, 1973). The basic premise of cross-impact analysis is that decisions leading to certain occurrences will in turn increase the probability of other unforeseen occurrences. For example, a decision to continue the development of nuclear power will result in large amounts of nuclear waste, which will in turn increase the probability of cancer in the population.

The cross-impact method requires the identification of important elements in the particular system being studied, identification of the interactions between those elements, and estimation of the strength of those interactions. Hard data as well as subjective judgments are used in these estimates.

As the relevant information is collected, a model is constructed. This model can be in the form of a simple chart or a complex computer program which keeps track of the data and the relationships between system elements. Using the model, the projected outcome of different specific scenarios can be found.

The major drawback to cross-impact analysis is the vast amount of information that must be gathered and then processed (Hetman, 1973). So far, in fact, only interactions between two elements can be considered at a time. When multiple impacts are included the processing time increases enormously.


1.0
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1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

5. Morphological Analysis

One method of forecasting is used by people who want to consider all possible solutions to a particular problem, or all possible paths to a desired future state, before choosing the best alternative. This method is called morphological analysis.

In a morphological analysis, the specific problem or desired future state is specified as precisely as possible. Then all possible steps from the present state to the end state are mapped out with the help of a matrix ("morphological box") or network diagram ("contingency or relevance tree"). Each step is weighed with some value representing its feasibility, desirability, or impact. Possible routes between these steps are traced to represent all possible paths or solutions, and the best solution is chosen (Hetman, 1973).

Morphological analysis is akin to management tools known as network or shortest path models (Wagner, 1975). It is useful mainly for organizing complex networks of possible events or subsystems in a particular system. As such, this type of analysis suffers from the difficulty of having to identify all possible events or alternate steps in a path to a certain future state.

6. Modeling

The final category of forecasting methods we shall consider is the very diverse field of models. In a sense, all forecasting techniques involve models because a model is simply an idea of how the world is and, thus, how it will be. But there is a distinct branch of forecasting that utilizes formal mathematical models that are usually quite complex, requiring the assistance of a computer for their design. Several subcategories of models can be defined, but we will not go into great detail concerning these.

The basic idea of a formal model is that the world, or that aspect of it that interests us, can be expressed in mathematical terms. The important elements of a particular piece of the world, or a system, are identified. The relationships between the elements are then identified and an attempt is made to mathematically describe the nature of the relationships. Cross-impact analysis is a form of model-building.

Once the system is defined in mathematical terms, the equations are solved for some future data. A general term for this process is simulation. We use a model, which is a representation of a particular system, to simulate the future state or development of that system. Simulation modeling is summarized in an article by Mihram (1974).

Some of the major types of formal modeling are: econometrics, input-output analysis, optimization, system dynamics, and energetics. A good comparison between them can be found in Meadows (1977).

The basic advantage of using formal models in forecasting is the ability to consider complex interactions. Processes such as feedback, simple cross-impact, delayed effects, and complex non-linear relationships between elements can be incorporated into a model (Forrester, 1971; and Meadows, 1972). Another important advantage is the precise mathematical statement of the assumptions of a forecast, an element not found in scenario writing or other less rigorous techniques.

A disadvantage of modeling is the problem of estimating relationships between elements that are difficult to measure, such as the response of gasoline consumers to gas prices or the effect of protein shortages on female fertility. Elements and interactions that appear important in the system are often very difficult to represent mathematically.

Modeling has been used extensively in the field of energy policy research, as well as in other fields where complex problems have been identified. Three good surveys of energy modeling can be found in Hoffman and Wood's "Energy System Modeling and Forecasting" (1976), Charpentier's A Review of Energy Models (1974), and U. S. House of Representatives Middle- and Long-Term Energy Policies and Alternatives (1976).

D. SOCIAL INDICATORS

Hand in hand with the development of methods to forecast future trends and events has been an attempt to monitor the effect of past and current trends on society as a whole. Various indicators have been developed to tell us where we are now in terms of where we have been and, at times, in terms of where we would like to be.

There are the familiar economic indicators, whose position along a specific trend is supposed to indicate a more or less desirable state of affairs. Unemployment statistics, the cost of living index, and the Dow Jones average are typical examples. Predicated on the work of the economists, a series of Social Indicators has been devised by social scientists. A social indicator is defined as:

> ...a statistic of direct normative interest that facilitates concise, comprehensive, and balanced judgments about the condition of major aspects of the society. It is in all cases a direct measure of welfare and is subject to the interpretation that, if it changes in the "right" direction, while other things remain equal, things have gotten better, or people "better off" (U. S. Department of Health, Education and Welfare, 1969).

Proponents of social indicators claim that such statistics will help decision-makers to rationally plan and manage society by providing them with statistical check-points along the way--check-points that will make it possible to check the accuracy of their forecasting techniques. Social indicators will also enable society to set priorities and evaluate programs by measuring the degree of attainment of stated goals.

A recent government publication, prepared by the Office of Management and Budget with the assistance of the Department of Commerce, examined eight major social areas in which improved social statistics and analysis have been developed: health, public safety, education, employment, income, housing, leisure and recreation, and population. The study claimed that for each indicator there was a widely held basic social objective or definition of a satisfactory condition:

> ...good health and long life, freedom from crime and the fear of crime, sufficient education to take part in society and make the most of one's abilities, the opportunity to work at a job that is satisfying and rewarding, income sufficient to cover the necessities of life with opportunities for improving one's income, housing that is comfortable within a congenial environment, and time and opportunity for discretionary activities.... For each of these social areas one or more indicators (or) statistical measures... have been identified.
>
> Ideally, an indicator would show, in a timely fashion, the status of the population in relation to a particular concern. It could be disaggregated to show which groups of the population were affected, and it could be linked statistically with other indicators to relate change in one condition to change in another. Thus, an indicator would reveal not only the status of the population in relation to a perceived social objective, but it would also furnish some idea of what forces were influencing that status. At the present time, not enough is known about the cause and effect of social conditions to develop such ideal indicators. Rather, the indicators presented in this publication represent simply a first step toward the development of a more extensive indicator system (OMB, 1973).

One outcome of this sort of social accounting has been the attempt to develop measures of "quality of life" (SRI, 1975; Liu, 1975; Perloff, 1969). While this is a very diffuse term, some effort has been made to correlate specifically the concerns of quality of life with "master social indicators" (SRI, 1969).

The most successful indicator efforts, however, have been involved with the relatively "hard" areas where quantifiable changes in specific environmental parameters can be detected. Many individual Environmental Quality Indices (EQI) have been developed for such things as air and water quality, noise, radiation and toxic substances levels, wildlife indices, etc. (Thomas, 1972). A substantial portion of an early annual report of the U. S. Council on Environmental Quality was devoted to the quest of comprehensive EQI (CEQ, 1972).

E. APPLICATION OF FORECASTING METHODOLOGY

Throughout the history of modern forecasting, attitudes about the field and its usefulness have gone through some very important changes. These developments can be seen if we look at two general areas where forecasting has been applied. We shall consider the area of "technology assessment" and the special case of the "limits-to-growth" controversy.

1. Technology Assessment

Modern forecasting began with the RAND Corporation and its attempts to evaluate the potential impacts of certain technological devices. In earlier days, and in some cases today, such an evaluation would be limited to easily measured technical or economic aspects. For example, two studies were done in the early 1970s to examine the development of telecommunications (NAE, 1971; EIA 1969 cited in Hetman, 1973). These studies analyzed the technical and economic developments in telecommunications that were expected to occur over the subsequent 10 to 15 years. This included a look at several fields such as telephone, cable TV, high speed data services, etc., and the networks needed at local and national levels to most efficiently implement new devices. The impacts of interest in this method of analysis tend to be fairly well defined, easy to measure, and technical or economic in nature.

The demand for technology assessment studies grew along with a growth in the complexity of technology. New devices such as atomic weapons, nuclear power plants, supersonic transports, and oil super-tankers are indicative of the technologies that began to emerge in the 1950s and 1960s. Such modern technologies are significantly very complex, requiring extensive management. They are very costly to initiate. As a result, they are sometimes limited to development by the government or by conglomerates of large corporations that can finance the required capital investment; and such technologies tend to contain very large potential health hazards.

As these technologies emerged, and the art of technology assessment began to develop, so did a new public attitude and awareness about technology in general. (See, for example, Daddario 1971; Starr 1969.) It is difficult to say which is the chicken and which is the egg, or even if the relationship is that close. But, for whatever reasons, technology came to be looked upon by suspicious eyes for the first time.

Traditionally, especially in the history of industrial America, inventions, processes, and science in general have been considered to be essentially beneficial, with no real associated moral value. The moral questions surrounding industry were confined to labor relations, antitrust suits, etc. With the advent of nuclear weapons, a few scientists began to question the amorality of science. In time, the general public began to notice that technological "advances" could have some negative aspects. For the first time science was being questioned; and the social, medical, psychological and political impacts of new technologies became an issue (Weinberg, 1972).

As a consequence of this convergence of big technology, public concern, and methods for assessing the impact of technologies, the field of forecasting opened up to a wider scope (Kauffman, 1976). People outside of business and the military wanted to know about the effects of many new technologies. Questions were asked that had never been adked by scientists and technologists.

It was within this environment, and because of it, that forecasting methods increased in number as different people tried to find different ways to estimate the social impacts of different technologies. Forecasting changed from a tool of technologists into a two-edged sword wielded also by questioners of such technologies as nuclear power, the birth control pill, the SST, automation, television, and electronic eavesdropping.

Technology ceased to be neutral during the 1960s and early 1970s. It was no longer free to develop in a social vacuum. A new idea emerged that governments, as defenders of the public welfare, should be held responsible for the correct development of technology (Baden, 1974; Henderson, 1975). Technology assessment evolved into a method for evaluating the effect of technology on society rather than just evaluating technology itself.

From the early methods used by RAND, technology assessment developed into a comprehensive tool for holistic evaluations of the effects of technology. The definition used by the Congressional Research Service of the American Library of Congress described this widened scope:

> Technology assessment is the process of taking a purposeful look at the consequences of technological change. It includes the primary cost-benefit balance of short term locales of market place economics but particularly goes beyond these to identify affected parties and unanticipated impacts in as broad and long range fashion as possible. It is neutral and objective, seeking to enrich the

information for management decision. Both "good" and "bad" side effects are investigated since a missed opportunity for benefit may be detrimental to society just as is an unexpected hazard (Hetman, 1973:57).

Today, technology assessment comes in many forms. It is not a particular type of forecasting, but is rather a particular strategy for applying forecasting methods.

A recent study conducted by the Department of Engineering-Economic Systems at Stanford University (Armstrong, 1977) attempted to outline the basic functional elements of the Technology Assessment (T.A.) process. It developed a generic strategy for the conduction of all technology assessments. Pictured below are the functional and cross-cutting elements of this overall assessment strategy.

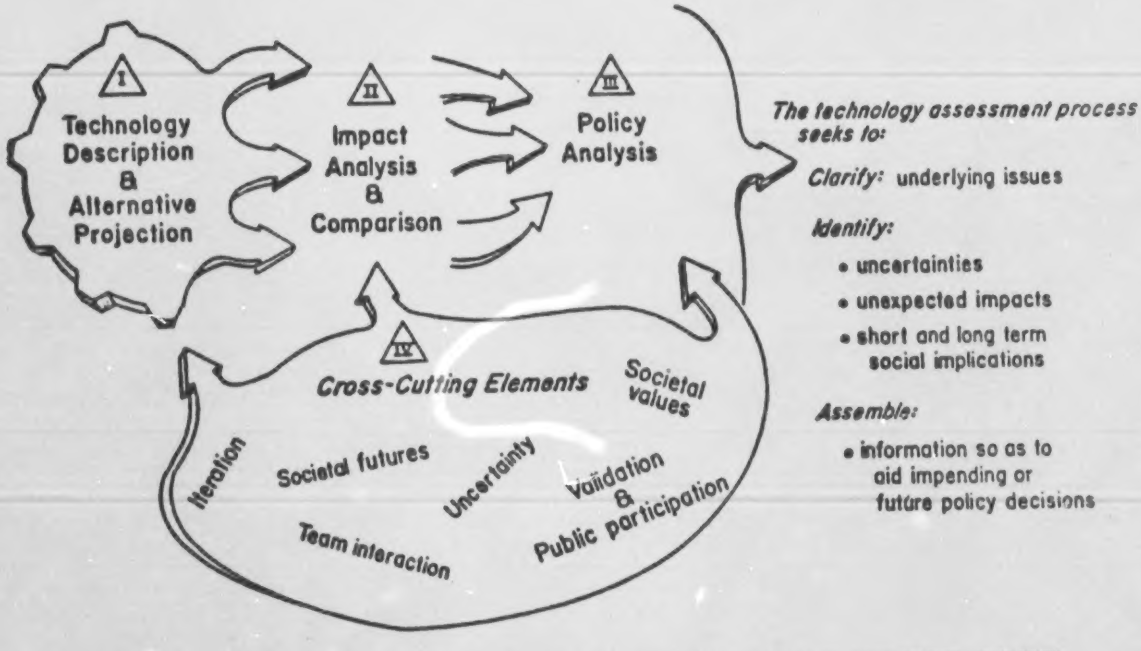

I
Technology Description & Alternative Projection
II
Impact Analysis & Comparison
III
Policy Analysis
IV
Cross-Cutting Elements
Societal values
Iteration
Societal futures
Uncertainty
Validation & Public participation
Team interaction
The technology assessment process seeks to:
Clarify: underlying issues
Identify:
• uncertainties
• unexpected impacts
• short and long term social implications
Assemble:
• information so as to aid impending or future policy decisions

Figure 1. FUNCTIONAL AND CROSS-CUTTING ELEMENTS OF A TECHNOLOGY ASSESSMENT STRATEGY

Four sequential functions are considered essential in the conduction of any Technology Assessment (see Figure 1). A description of each of these functions, and the concerns (i.e., cross-cutting elements) that must be dealt with in carrying out the functions, is as follows:

TECHNOLOGY DESCRIPTION AND ALTERNATIVE PROJECTION:	The current state-of-the-art of the technology is defined and projected into the future along feasible alternative paths.
IMPACT ASSESSMENT:	Comparative evaluation of the technological alternatives is performed. These comparisons should be based on social and environmental criteria as well as on the concern for technical, economic, and legal feasibility.
POLICY ANALYSIS:	The technological alternatives are compared as to the feasible policy options open to the policy-making community.
CROSS-CUTTING ELEMENTS:	In the process of carrying out the functional tasks, a number of concerns must be dealt with, one way or another. These cross-cutting concerns (societal features, societal values, uncertainty, public participation, etc.) deserving special attention are grouped in this fourth major element of T. A. methodology.

The use of various forecasting methods (expert opinion and group consensus, trend extrapolation, scenario writing, etc.) is crucial to the performance of each of these functional stages. The use of forecasting methods throughout the stages of a Technology Assessment could prove to be a very effective tool in the holistic assessment of our society's future.

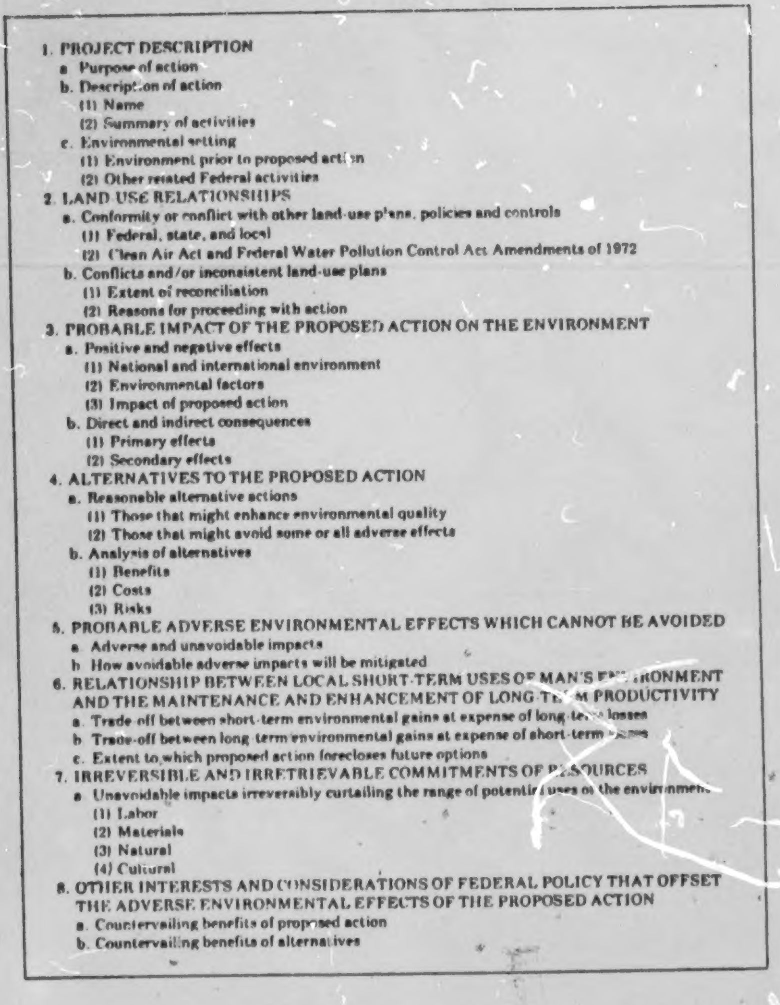
Further discussion of the general framework encompassing types of technology assessment, with reference to many specific subjects of application, can be found in Armstrong (1977) and

Hetman (1973).

As discussed in Hetman (1973), the following are examples of some particular areas in which technology assessment is being applied:

- the monitoring of negative side effects of existing technologies;
- resource recycling;
- new scientific discoveries and research areas;
- desirable new technologies.

A very important sub-category of Technology Assessments concerns what is called Environmental Impact Analysis (Ditton, 1972). Among other things, the National Environmental Policy Act requires all governmental units spending federal funds to assess the environmental impact of any proposed project. These assessments must be filed with the President's Council on Environmental Quality (CEQ) and appropriate state agencies. Many states have legislated similar requirements, extending the concept down to county and municipal governments. An elaborate reviewing procedure seeks comments by citizens, university scientists, sister agencies, etc., in the assessment of environmental impact statements (EIS). The outline of CEQ-prescribed Environmental Impact Statement content, cited on the following page, indicates the intended comprehensiveness of the statements and the extent to which various forecasting methods are necessary.



1. PROJECT DESCRIPTION
   a. Purpose of action
   b. Description of action
      (1) Name
      (2) Summary of activities
   c. Environmental setting
      (1) Environment prior to proposed action
      (2) Other related Federal activities
2. LAND USE RELATIONSHIPS
   a. Conformity or conflict with other land-use plans, policies and controls
      (1) Federal, state, and local
      (2) Clean Air Act and Federal Water Pollution Control Act Amendments of 1972
   b. Conflicts and/or inconsistent land-use plans
      (1) Extent of reconciliation
      (2) Reasons for proceeding with action
3. PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT
   a. Positive and negative effects
      (1) National and international environment
      (2) Environmental factors
      (3) Impact of proposed action
   b. Direct and indirect consequences
      (1) Primary effects
      (2) Secondary effects
4. ALTERNATIVES TO THE PROPOSED ACTION
   a. Reasonable alternative actions
      (1) Those that might enhance environmental quality
      (2) Those that might avoid some or all adverse effects
   b. Analysis of alternatives
      (1) Benefits
      (2) Costs
      (3) Risks
5. PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED
   a. Adverse and unavoidable impacts
   b. How avoidable adverse impacts will be mitigated
6. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY
   a. Trade-off between short-term environmental gains at expense of long-term losses
   b. Trade-off between long-term environmental gains at expense of short-term gains
   c. Extent to which proposed action forecloses future options
7. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES
   a. Unavoidable impacts irreversibly curtailing the range of potential uses of the environment
      (1) Labor
      (2) Materials
      (3) Natural
      (4) Cultural
8. OTHER INTERESTS AND CONSIDERATIONS OF FEDERAL POLICY THAT OFFSET THE ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION
   a. Countervailing benefits of proposed action
   b. Countervailing benefits of alternatives

Figure 2. OUTLINE FOR CEQ-PRESCRIBED EIS CONTENT

Some people have begun to conceive of technology assessment as a valuable tool in improving our society. Hazel Henderson, in particular, sees technology assessment as an important meeting ground between the technical, reductionist thinking of science and the holistic, systems-oriented thinking of environmentalists and others (Henderson, 1975).

An important element of this viewpoint is public participation in the assessment of technology and the values underlying technological developments. With an analytical framework such as this, the implicit goals and values of scientific "progress" become explicit and, thus, available for public evaluation. This tool will then help society to clarify its goals before plunging head-first into an uncertain future ruled by large-scale technology.

2. The Limits to Growth Controversy

All forecasting methods are essentially value-free, neutral tools used for a particular purpose. But methods differ because they are based on different assumptions about the world. For example, the method known as trend extrapolation is based on the assumption that no surprising changes will occur, that the machinery of the world moves slowly in one predictable direction. Cross-impact analysis, on the other hand, assumes that surprises are lurking in the wings and can be aroused by a certain sequence of events.

The assumptions underlying different forecasting methods are, in a sense, indicative of the bias of the people who develop and use them. Certain methods are more popular with economists than with political scientists, who have methods more in tune with their own view of the world. For this reason, different forecasting methods can generate conflicting results when applied to the same problem, just as two people can have different expectations of the world. Thus, no particular method is totally objective and any forecast may be subject to criticism from people with conflicting views.

The best example of this phenomenon centers around a particular study released in 1972. The study, sponsored by an elite group of scientists and industrialists known as the Club of Rome, was summarized in a book entitled The Limits to Growth, written by four researchers from the Massachusetts Institute of Technology (Meadows, 1972).

The Limits to Growth study was based on a foundation developed by Jay W. Forrester and presented in his book, World Dynamics (1971). The basis of the study was a computer simulation model, one particular forecasting tool, that attempted to mimic the worldwide dynamic interactions of population growth, food supply, capital investment, pollution, and resource depletion. The general conclusion of the study, using this model, was that under the most likely circumstances the world system will proceed on its current path of exponential growth of population and capital until the life-support capacity of the earth is surpassed and, at that time, the human social system will collapse.

This pessimistic projection of the future was very persuasive due to the computer-assisted forecasting method used. This particular type of modeling, called system dynamics, is especially well suited for dealing with very complex interactions in systems. Due to the use of computer data, the study had a much stronger impact than such doomsaying in the past.

Two basic characteristics of The Limits to Growth study were also the two main targets of criticism. The first criticism was of the use of computer-aided forecasting to make such a strong and relatively surprising statement about the future. The other criticism was directed at the nature of the statement made--a direct challenge to the blind allegiance to the status quo and the values underlying our social system.

The literature generated in response to The Limits to Growth was truly phenomenal in volume as well as in content. Criticism and support came from all segments of society. Criticisms ranged from very technical attacks on the model itself or on the system dynamics methodology (Cole, H.S.D., 1973; and Cole, P., 1973), to the questioning of the assumptions about the world embodied in the report (Cole, P., 1973; and Berry, 1972), to a simple refusal to accept the conclusions of the report regardless of how validly they may follow the assumptions of the model (HEW, 1973). The criticisms and support were so numerous that only a few are listed here. Those listed will no doubt lead you to others and so on, ad infinitum.

Right or wrong--and the controvery is still unsettled--The Limits to Growth touched off an important process of questioning and debate in our society. A brief summary of this debate will help to clarify the current interest in the future that has led to so much criticism and development of policy-making in general, and the use of forecasting in particular.

It is no secret that our society is growth-oriented. The goals of ever-increasing production, consumption, and GNP are built into the very structure of our economic institutions. Communities as well as corporations are bent on expansion: world population continues to grow at increasing rates while governments encourage growth. The underlying economic theory is that only by increasing the total amount of material wealth will there be enough for everyone to have an adequate share (Passell, 1973).

The Limits to Growth was not the first challenge to this type of growth-mania, but it has been the most successful. The basic message of the study was that there are limits to the amount of human activity that the earth-system can take. There is a limit to the amount of food that can be produced to feed people, a limit to the resources that can be turned into devices soon discarded, a limit to the amount of pollution that can be assimilated by our life-support systems. Further discussions brought to light the strong probability that there are also social limits--the amount of crowding people can tolerate, the conflict arising from competition for "positional" goods and from unequal distributions--as well as political limits regarding the management of great volumes of activity (Hirsch, 1977; Population Commission, 1972).

In a growth process, these physical limits define the level to which a system can grow without developing a lot of problems. The system can grow further, even beyond its limits, but this will likely result in damage to the supporting elements in the system--such as useful farm land and fresh water to assimilate pollution--so that new limits will develop at a lower level. (These principles, derived from the science of cybernetics, are explained in Meadows, 1972; Forrester, 1971; and Meadows, 1974.)

Part of the limits-to-growth debate focuses on the existence of such limits and their nearness to us (USHR 93-28, 1973). While the limits are difficult to measure, many participants in the debate have accepted their existence and have begun to plan for an alternative future. The alternative to continued growth (at whatever cost) that has come to the forefront is a fairly new body of ideas known as "steady-state economics." A major expression of these ideas can be found in Daly (1977).

The basic premise of steady-state economics is that the world system can slow down its growth and level off comfortably before the limits to growth are reached. Such a future would require some radical changes in attitude and in institutions, but these changes may be essential. New social institutions will be needed to see that society's wealth is distributed more equitably. The limits-to-growth debate has developed into a debate between traditional economists and steady-state economists. A good summary of this debate can be found in Henderson (1973).

There are many lessons to be learned from the issues in the limits-to-growth debate. The most important lesson is that "the future isn't what it used to be"; we can no longer allow things to continue in accordance with the principles of traditional economics. We have an obligation to plan for the future and to put all of our knowledge to good use. Such an effort must include our knowledge of the principles active in complex systems, as well as the observed principles of traditional economic systems. We need to allow for more public participation, through government, in planning and adjusting for the future.

In the case of The Limits to Growth, forecasting was used to enlighten the public regarding important issues. Whether people accept the gloomy results of the study and buckle down to the difficult job of adjusting the system or reject the study as being too simplistic or biased toward reactionary environmentalism, the issue has now at least been considered by many different people in many different fields. The resulting discussion has helped to clarify national goals and has influenced policy-making. Some important documents influenced by this controversy include Population and the American Future, the report of the Commission on Population Growth and the American Future (Population Commission, 1972), and an excellent compendium of articles entitled Growth and Its Implications for the Future, compiled for the U. S. House of Representatives (USHR 93-28, 1973). A technical report explaining in detail the assumptions of the computer model used for The Limits to Growth study is published as The Dynamics of Growth in a Finite World (Meadows, 1974).

F. THE FUTURE OF FORECASTING

There are several factors prevalent in our society that suggest a growth in the use of forecasting. Our technical and social problems continue to grow in complexity and to evade simple solution through the free market or democratic systems. At the same time, forecasting techniques are becoming more sophisticated, we are gaining experience in problem-identification, and we are beginning to understand the basic principles of complex systems. Added to these factors are an ever increasing public awareness of complex problems and a related public concern for guiding society's path into the future.

As forecasting becomes more sophisticated, there is a danger that it will become a tool of only a select, informed group of individuals. But as the general public begins to understand the utility and limitations of forecasting, trust in such enigmatic forecasting will decrease accordingly. It seems reasonable to expect that forecasting will become an increasingly important input to decision-making, and a tool for clarifying society's goals and the paths to these goals.

Several excellent discussions of the future of forecasting and future studies in general are listed in the bibliography.

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FUTURES
THINKING

A. INTRODUCTION

For individuals faced with choosing one of many diverging pathways in life--whether to get married, now or later, to this person or perhaps wait for another--the future is an unknown experience, shaped partly by choices made today. Many of these choices are very difficult to make. For one thing, each choice feels so "awe-fully" important; then, too, along each path the future is only dimly visible. Nevertheless, one perceives certain consequences of the decision, and make a choice, consciously or not, based upon a relative evaluation of those consequences.

Now consider a society faced with choices. Any decision a society makes affects its future; yet we do not usually conceive of a society "choosing its future." Apart from the quick answers of the standard ideologies, it is much more difficult to imagine what the future will hold for a society as a whole. The profound consequences of a nuclear society, for example, have hardly been explored, yet the large-scale decisions for our nation's energy policy are currently being made; and this policy can determine our futures for centuries to come.

It should seem reasonable, then, that some people are immersing themselves in speculation about the long-term future of a society, or of human civilization as a whole. These people may be called "futurists." One does not have to be an "expert" to be a futurist; the future is locked inside each of us.

Why do these souls romp in this realm of fantasy and dreams of the future? For a couple of closely-related reasons. One is to illumine the present: our conception of the future shapes our decisions today. Macrohistorians look for large-scale trends in the records of civilization; it is said that the perceived future plays a clear role in motivating the society:

> Any student of the rise and fall of cultures cannot fail to be impressed by the role played in this historical succession by the image of the future. The rise and fall of images precedes or accompanies the rise and fall of cultures. As long as a society's image is positive and flourishing, the flower of culture is in full bloom. Once the image begins to decay and lose its vitality, however, the culture does not long survive. (Polak, 1973).

It is somewhat paradoxical that something that has not yet happened--and therefore does not exist--participates in a cause-effect relationship. We usually consider only the influence of the past, and not the future, on the present state of affairs.

A more conventional way to view our relationship with the future is the converse--i.e., that we can change the future by our present actions. It should be obvious that the actions we take--nearly all of them--are done to improve our future situation. This is another illustration of the importance of futurists' efforts: if we CAN shape the future, we want to do it WELL. As the American inventor Charles F. Kettering said, "My interest is in the future because I shall spend the rest of my life there."[1]

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[1] Charles F. Kettering, Seed for Thought (1949).

A. INTRODUCTION

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B. THE WORK OF FUTURISTS

Just what is it that futurists do? Their function could be described as "generally exploring or delineating the 'dimensions of uncertainty' of the future." The future certainly cannot be known accurately; but, consideration of the nature of the past and present can make it possible to describe the future with reasonable probability. This implies, however, the existence of several assumptions, which form a basic philosophy of futurism.

The most universal assumptions adopted by futurists are:

Societies exhibit continuity.

> Social systems change smoothly from one state to another; generally they do not change in discontinuous jumps. (Even during relatively disruptive and seemingly discontinous periods, such as the American Civil War or the French Revolution, much of the culture, social roles, and institutional framework of a society persists without fundamental change.) Thus, in making forecasts futurists commonly and reasonably extrapolate from past experience. This principle of continuity is used in all sorts of projections of trends and cycles--for forecasting demographic trends, economic cycles, and annual energy consumption; for anticipating future attitudes from polling data; for estimating future financial performance. (Harman, 1976)

Herman Kahn's (1976) projections of a "basic long-term multifold trend" of industrialized society, and Daniel Bell's (1973) projection of a "post-industrial society" are classic examples of societal trend projections based on this assumption. Whereas George Cabot Lodge, in postulating a "new American ideology" (1975), offers an example of a projection based on a presumed deviation from past trends:

Social systems tend to exhibit *__self-consistency__* *in their internal structure. They are organism-like.*

> Stable societies have powerful cohesive forces such that it is unlikely that two different parts of the society can go in radically different directions for very long. Technological forecasts that presume continued vigorous technological development imply an assumption that the cultural values and attitudes will be such as to support that development. Projections of high future energy demands assume that the lifestyles underlying those energy requirements will not change significantly; contrariwise, those who forecast some sort of major shift in the priorities and goals of the economy. Scenario construction is one of the techniques used in futures research to test for continuing self-consistency through time. (Armstrong, 1977)

Familiar examples of scenario-writing include the science fiction of Verne, Wells, Huxley, and Orwell, which will be elaborated on in later sections.

Social systems appear to contain *__cause-effect__* *linkages, or to show correlations that imply cause-effect or stochastic linkages.*

> For instance, in making economic projections, it may be assumed that if scarcities occur, prices will rise; or that if the money supply is manipulated to decrease inflation, unemployment will increase. Such presumed cause-effect linkages underlie much economic and simulation modeling. They comprise the basic principle underlying the method of cross-impact analysis, in which aspects of the future are studied through the presumed interactions of contributing events on one another. (Armstrong, 1977)

This supplied the basis for the now classic study, __The Limits to Growth__ (Meadows, et al., 1972), by the Club of Rome.

The *__future is malleable.__*

> At any given moment, therefore, there exists a __range__ of alternative futures which might come about. History and physical reality determine which futures are in that range. Chance and human choice will determine which one of those possible futures will actually happen....
> The purpose of futuristics, therefore, is not to predict the future, but rather to improve our understanding of the range of alternative futures which might come about and of the role that both chance and deliberate choice might play in either achieving or avoiding any particular future. (Tugwell, 1973)

In short, it is assumed that there is something dependable about the behavior of social systems, that they follow discernible trends, have a fair degree of inner consistency, and resemble each other in certain basic respects.

Futurists, then, using these assumptions and their unavoidably limited knowledge of social systems, attempt to construct the available pathways to a series of alternative futures.

There is, of course, ample room for the values of the futurist to affect the study. Indeed, to many the "central issue" of futurism involves deciding which alternative futures are to be considered "feasible." While ostensibly that seems to be a relatively objective matter, in reality it tends to be a very subjective one. In fact, as Edward Cornish, President of the World Future Society notes, the futures field itself is undoubtedly biased--it has already undergone an extreme self-selection process, since most futurists are quite optimistic (Cornish, 1977).

> "If you are excited by the future, you are more likely to become a futurist; otherwise, you'll find something else which is more 'rewarding'. The optimism of futurists may derive more from their emotions and basic personality structure than from any rational, scientific analysis of the human situation in the 20th century (Cornish, 1977).

This only serves to emphasize the importance of our belief systems, for "in social systems more may depend on what people think will happen than on the realities" (Cornish, 1977). Inflation, for example, is more likely affected by changing "consumer expectations" than by federal defecit spending. If most people believe that the coming year will be inflationary, it almost surely will be.

It is this type of insight that prompted Philip Slater to write, "every morning all 200 million of us get out of bed and put a lot of energy into creating and re-creating the social calamities that oppress, infuriate, and exhaust us" (Slater, 1976).

There is, then, a very real "self-fulfilling prophecy effect" in futures thinking. Those futurists whose projections are widely known may very well alter people's expectations and thereby "change" the future tide. It is widely acknowledged, for example, that the writings of Jules Verne have influenced the future he was writing about. In fact, his success as a forecaster appears to be due in no small measure to the fact that many of his readers were inspired to realize the inventions and feats he dreamed of (Cornish, 1977).

Of course it can also work the other way: the alarming projections of the Club of Rome (Meadows, et al., 1972) may very well serve to alter the envisioned disaster.

Either way, it should be noted that this "feedback" gives popular futurists a great deal of power to affect the future, because the "measurement" of the future that they make is filtered through their own perceptions. This demonstrates the importance of understanding the worldview and value system of your forecaster. (See section on WORLDVIEWS.)

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C. THE WORLD MEGACRISIS AND A NEW SENSE OF URGENCY FOR FUTURISM

Widespread interest in futurism is a fairly recent phenomenon. This is primarily due to a new sense of urgency. Industrialized societies have suddenly been swamped by a multitude of unintended and unwanted "side-effects" of their progress.

In spite of an enormous human propensity to deny the obvious, the crises facing the world today have become too widespread to ignore. Continuing environmental deterioration, the Mideast crisis, and the ensuing energy crunch, widespread famine and economic woes, all threaten the world community. The multiple nature of the crisis has led Willis Harman (Director of the Center for Study of Social Policy at Stanford Research Institute International) to term it a megacrisis, or "crisis of crises" (Harman, 1976).

The factors contributing to this megacrisis are numerous, as are the roadblocks to its solution. A product of our own lack of foresight and planning, the current megacrisis is not unlike raising our own child whose delinquency we are at a loss to explain.

Switching to a long-range view of the future is not that easy. Over the years, we have built many impediments to long-range planning into our social and economic systems. Draper Kauffman, in Teaching the Future, identifies and examines some of these inherent roadblocks to long-range planning:

24 REASONS WHY WE LACK FORESIGHT[1]

POLITICS:

- Two- to six-year terms of office.
- Lack of public demand (or even tolerance) for anticipatory action.
- Tendency to praise or blame incumbent for situations his predecessor created.
- Vicious circle from lack of foresight--"the perpetual double bind."

ECONOMICS:

- Inability of market to function with very long reaction-times.
- "Discounted future values"--interest rates dominate social foresight.
- Paper economics applied to perishable real resources.
- "External" costs minimize true long-term costs.

FORECASTING ABILITY:

- Increasingly rapid change, thus increased difficulty (and necessity) of forecasting.
- Primitive methods.
- Scarcity of funding and of trained forecasters.

HISTORY/IDEOLOGY:

- Long period with the wealth and physical space to absorb mistakes.
- Faith in the inevitability of "progress."
- Patriotic belief that "the American system" is so good that it is self-guiding (or divinely guided).
- Fatalism (from religion, apathy, or felt impotence) and "presentism"--live each day one day at a time.
- Withdrawal from future shock.
- Collapse of a shared sense of national purpose.

THE MEDIA:

- Lack of conceptual sophistication about the future.
- Lack of means for (and interest in) judging scientific competence.
- "Orthodoxy of optimism," derisive attitude toward those who warn of problems.

EDUCATION:

- Historical orientation toward the past.
- Traditional and glacially unresponsive bureaucracy.
- Built-in 10- to 50-year lag-time.
- Lack of recognition by parents and educators of the need for anticipation in a rapidly changing society.

(Kauffman, 1976, p. 208)

It is clear that as we attack the various dimensions of this megacrisis we must, as many futurists contend, directly address the inherent institutional impediments.

What are the factors that have contributed to the world megacrisis? Numerous philosophers, economists, and assorted social analysts have turned their attention to the current world situation in an effort to understand its origins and discover its future direction. Kenneth Boulding (1961, 1964), Alvin Toffler (1970, 1972), Herhman Kahn (1967, 1976), Margaret Mead (1970), Willis Harman (1976), and Garrett Hardin (1972), are but a few of the individuals who have important things to say about the fundamental causes of the crisis and the options open to us.

1. Accelerating Social Change

Perhaps nothing in all of history is so startling as the relatively recent acceleration in the rate of change. There are individuals living today whose early memories do not include such common things as electricity and the automobile, much less the airplane or atomic energy. Indeed, it was only years ago that manned spaceflight was but a dream of science fiction writers; today, manned laboratories regularly circle the earth and there have been several successful visits to the moon.

The social and technological aspects of "change" are intertwined in an almost endless positive feedback cycle, and not all of the results are totally beneficial. Toffler, in his book Future Shock (1970), chronicled some of the negative personal and social effects of an ever accelerating pace of change. These effects include increasing levels of stress and related incapacitating illnesses, a sense of alienation and disorientation, an inability to deal with complexity, and a general depression. All are results of "futures" that arrive much faster than the development of the psychological and social mechanisms to deal with them.

The inability to cope with the pace and complexity of change leaves individuals less able to control the future buildup of stimulus overload. The ability to direct the changes in their lives has been almost totally taken out of their hands, and they become helpless in the wake of exponential rates of change.

As a society, we have grown to accept the concept that our actions in the present will eventually benefit us in the future. It is because of this concept that we continue to pour money into our social security system and insurance policies, abide by the conventions of serving apprenticeships, make financial investments, and spend a good portion of our lives in educational institutions. The increasing pace of change, however, is altering the validity of that assumption. Many people are left with the feeling that it is impossible to prepare for the future in such a rapidly changing world.

2. Complexity of Social Problems

It is becoming increasingly clear that the problems faced by society are multidimensional and cannot be solved with simple linear engineering solutions. The intuitive or "obvious" solution to problems often aggravates the situation instead of helping it (Forrester, 1969). The "obvious" solution to famine is an increase in the food supply. However, it is just as probable that an influx of food in famine regions would result on decreased mortality and increased birth rate, thus putting greater strain on existing supplies and creating an *increase* in the eventual amount of starvation in the future. Famine is the result of an interrelated set of factors, including the following: the dynamics of population growth; existence of arable land; the effect of poor farming practices and deforestation or erosion; loss of topsoil; changing climate and expanding deserts; mechanization of farming and requirements for expensive oil products; use of artificial fertilizers that are energy consumptive and may have long-term negative effects on soil quality; long-term effects of insecticides, both in terms of insect resistance and unwanted secondary and tertiary consequences; and various other political and economic considerations.

In other words, it is a very dynamic and complex *process* and not merely an *end-state* that will respond to simple remedial action.

The specific example of the use of DDT shows the complex nature of human/environmental problems. The pesticide DDT was used to deal with the malaria-carrying mosquito and various forms of crop infestation. While it initially succeeded in reducing the incidence of the target organisms, we now know that it also produced a multitude of side effects. It accumulated in both animal and human food chains to detremental levels and resulted in a natural selction process that has produced resistant strains of the pests that it was intended to destroy.

Futurists are beginning to realize that attempts to deal with world problems, indeed even local problems, must be interdisciplinary and cognizant of the fine web of interrelationships that connect everything together. There are, in effect, no simple decisions. Systems theory has provided us with a powerful tool in the analysis of these holsitc problems. To use this approach effectively, we must be predisposed to recognize that problems (and solutions) cannot be isolated from their larger context.

3. Thresholds, Lag Time, and Exponential Increases

Many aspects of the megacrisis were very slow in developing. In fact, the initial, gradual buildup of the problems is largely responsible for our inability to believe a crisis actually exists. We were lulled into a sense of complacency, not only by the relatively slow rate of change, but also by our past ability to deal with crises in an effective manner even after they had become critical. Our "crisis management" approach to problem solving is no longer adequate. Today, mistakes and untimely action can threaten the very existence of society.

Another major contributor to the megacrisis is the phenomenon of exponential growth. The cumulative effects of gradual increases in such things as population, energy use, and water or air pollution can be astounding. A small two percent annual increase in air pollution, for example, would mean that the air pollution level would double in 34 years. Perhaps even the first doubling might not be serious, but it does not take long for a series of doubling to get out of hand. Energy consumption has been doubling not only because of population increase, but also because of increased per capita consumption. The human population, the consumption of natural resources, and the adverse effect of both on the environment are all growing at an exponential rate. Increases that initially seemed very small are now exhibiting significant cumulative effects.

Exponential increases develop large amounts of momentum. In the case of the U.S. population, growth continues to take place for at least forty years after replacement birth rates are achieved. This phenomenon--the continuation of a problem even after action has been taken--is known as "lag-time." Another example of lag-time is the delay between attempts to make changes in the educational system and the actual incorporation of those changes in the system itself. If decisions are made to implement changes, there is typically a twenty year period before those changes actually become incorporated into the current system, and it usually takes a period of five years for the changeover process to occur.

The point of no return in the development of a crisis will often be passed long before the crisis is publicly evident, because of such things as lag-time. This point of no return is called a "threshold" and may also apply to the point at which certain problems actually become noticeable.

All of these factors make it imperative that society begin to exert considerable effort in the following areas: (1) examination of what the future holds in terms of potential alternatives; (2) identification of which of those futures are most desirable; and (3) formulation of the decisions that will increase the probability of desirable futures and will mitigate the danger of negative futures.

Even though we cannot be sure of the exact future, the knowledge that there are several possible futures can leave us forewarned and help to reduce the "future-shock" we suffer as individuals and as a society. The futures field, or futuristics, concerns itself with exactly those goals.[2]

4. The Futures Field

Roy Amara, President of the Institute of the Future, has isolated three general features of the futures field. These three features stem, in a general sense, from a definition of futuristics as any efforts to systematize our assumptions and perceptions about the future. The three categories are as follows (Amara, 1974):

- the exploration of possible futures (the art of futurism);
- the exploration of probable futures (the science of futurism);
- the exploration of preferable futures (the politics and psychology of futurism).

Using these general features, Amara goes on to define and interrelate the five basic functions or roles of the futures field in dealing with the world megacrisis and its component problems. (See Figure 1, and the accompanying explanations of the five basic functions.)

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[2] "Futures field" (or "futures") is used synonymously with "futuristics," "futurism," and "futurology." "Futures research" is used in a narrower sense to denote the research or analytical arm of the futures field.

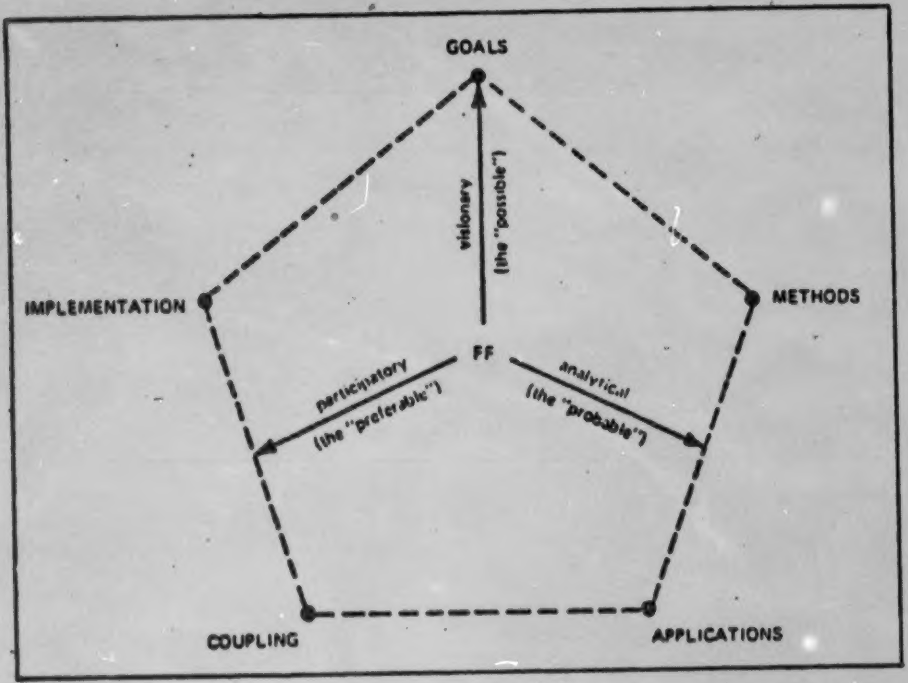

Figure 1. FIVE BASIC FUNCTIONS OF THE FUTURES FIELD IN RELATION TO THE WORLD MEGACRISIS

Goals Formulation can mean: issue or problem definition; future-image creation or alternative futures generation. It is directly related to the visionary component of the FF and is thus least explicit, most intuitive, and highly personal.

Methods development, including the development of a body of explicit, organized knowledge about event and trend forecasting, process modelling, and data integration. Together with the application-oriented function (see applications below), the methodological orientation stems from the analytical or research component of the FF.

Applications. One of the practical objectives of the FF is to provide inputs to planning and decision-making processes by helping to expand the range of useful alternatives, to evaluate future consequences of such alternatives, and to structure programs of intervention or action. This function may or may not involve the application of formal methodologies.

Coupling. It is difficult to describe adequately the process by which the results of futures research are assimilated--or not--by intended users--individuals, groups, or organizations. The function involves socio-psychological and organizational aspects as much as it does information transfer, since the objective is to infuence individual perceptions, behavior, and attitudes. Taken together with implementation, the coupling function is at the participatory roots of the FF.

> *Implementation*. Images, methods, and plans must eventually make themselves felt by "reduction to practice." Implementation actually embodies the end of one role and the start of another. It includes the interventions and actions actually taken to realize the objectives of a plan; at the same time it provides the information feedback (e.g., indicators) that may lead to the generation of different sets of goals, the development of new methodologies, or the initiation of modified programs of action.
>
> (Amara, 1974)

The basic assumptions that provide for a field of futuristics did not spring into being overnight. There is a long historical chain of events and philosophies that have brought us to our present view of the future. Before we proceed with our discussion of the field as it is today, we should look at the history of its development.

D. HISTORICAL DEVELOPMENT OF THE FUTURES FIELD

1. Fate, Doom, and Time

The current conception of the future--that it has some plasticity and can be consciously molded--is a rather recent historical phenomenon.

For millenia, both biological and social change moved forward so slowly that change from one decade to the next was all but invisible. Early civilizations and cultures could expect subsequent generations to live in essentially the same manner as they and their ancesters had. This legacy of experience had a profound effect in establishing a concept of changelessness. Seasons passed each year in an endless repetitive cycle. Rituals, prayers, and sacrifices made to various gods were not meant to alter the future, but to insure a continuation of the present.

Mythology is replete with references to "fate" and "doom." The future was thought to be predetermined--controlled by the gods with no chance of alteration by humans. Even the great oracles of Delphi could attempt only a glimpse of the inevitable. Such knowledge might allow you to carry out your fate with dignity, but not to escape it.

Several factors contributed to a changing view of the future. In carefully describing the conditions of the day, early historians such as Herodotus and Thucydides laid the foundation for a frame of reference against which cultural change could be measured in the future. Later, Renaissance minds, in rediscovering these works, could plainly see that considerable social evolution separated the two ages. This effectively drove a wedge into the traditional concept of changelessness and opened the door to the emerging concept of progress that is so closely intertwined with the Western notion of the future.

Equally important is the effect that Plato's philosophical speculations had on the twin concepts of progress and future. His Republic began a tradition of "utopian" writings that projected the vision of "ideal" worlds.[3] The most striking impact of his work is the attention it drew to the fact that there exists a qualitative difference in the systems that govern human affairs. To Greek philosophers, the intellectual inquiry into such concepts may have provided its own reward. To their intellectual successors, however, the effect of acknowledging a difference in the desirability of various social systems has contributed to a consideration of how certain desirable conditions might be brought about.

Judaism, and subsequently Christianity, exerted an additional influence by providing humanity with a worldview that included an active role in history. Instead of reacting to the whims of gods--trying to propitiate them with magic or anticipate their desires through oracles--people were viewed as willing partners with God in the continuing work of Creation. They could choose to follow the Instruction or not. The future was not predetermined; therefore, it was in the realm of human responsibility, and of hope.

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[3] See Bibliography for full references cited in this paper.

"Time" became altered as individual ethical responsibility became the motor of change. The present could be a discontinuity in time, as past and future could be separated. The Jewish instruction of the annual Day of Atonement reflects this attitide: the past mistakes can be forgiven; the past is not binding, so the future can be welcomed and approached with innovation.

The Prophets combined the new messages of free choice and time most incisively. They spoke of the future in order to elicit a new course of action. Religion passes, in Judaism, from a world of magic into a "form of progressive social criticism" (McHale, 1969).

Christianity later incorporated these ideas into the doctrines of "redemption" and "spiritual rebirth," which are oriented toward a Kingdom of God. Thus the idea of an alterable future was implanted even more firmly into Western thought.

The Dark Ages forced a hiatus in this emerging concept of the future. But beginning in the thirteenth and fourteenth centuries, and accelerating after that time, the notion of "progress" and of an alterable future began once again to take hold.

In 1516, Sir Thomas More wrote "Utopia," coining the word that would be used to describe all idealized speculations on social organization. In many ways, More's work was an extension of that proposed by Plato. Both perceived their societies to be controlled by "philosopher-kings" and ordained to continue unchanged for all time. They had made the broad leap necessary for identifying the existence of qualitatively disparate societies. There remained, however, another step on the road to a concept of "progress" that needed to be taken.

The individual largely responsible for taking that step was Sir Francis Bacon. Bacon's own utopian novel, New Atlantis, differed from that of Plato and More in several significant ways. The work described a science-based community in which all citizens had as their great purpose "the knowledge of the causes and the great motion of things, and the enlarging of the bounds of human empire, to the effecting of all things possible." Bacon insisted that the true purpose of science was to improve the lot of mankind. This differed significantly from the philosophical perspective of the early Greeks, who viewed the pursuit of science merely in terms of speculative satisfaction. Bacon helped bring about an era that had "great confidence in the ability of man to improve his condition through science and industry."[4]

2. Progress and Social Order

It was Bacon's vision of cultural change and the role that science and technology might play in molding these changes that encouraged an active involvement in shaping the future. It was Bacon who first formulated a concept of "progress": the movement of civilization in desirable and positive directions. This vision of progress was to become, according to historian Warren Wagar, "the religion of modern man."

The ideas of Bacon were championed in the intellectual battles of the "Enlightenment" by the "Moderns" such as Bernard de Fontenelle, who argued in Dialogues of the Dead (1683) and

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[4] I. F. Clarke, "Bacon's New Atlantis: Blueprint for Progress," Futures, 4:3 (1972), pp. 273-279.

Digressions on the Ancients and Moderns (1688) that the intellectual achievements of succeeding generations must inevitably accumulate.

This kind of argument was a watershed in human thought and by the nineteenth century it was well accepted as "part of the conventional wisdom."

It was first asserted by Bacon, and assumed by many others, that since science (knowledge) feeds technology, which improves the human condition, then if knowledge continues to grow, human happiness must inexorably increase. Can Utopia then be far off?

It appears that this doctrine has always been carried forth single-mindedly by some, yet treated with skepticism by others, from Bacon's day through our own. For example, Ben Franklin greeted it with a somewhat tempered optimism in a letter to Joseph Priestley in 1780:

> The rapid progress true science now makes occasions my regretting sometimes that I was born so soon. It is impossible to imagine the height to which may be carried, in a thousand years, the power of man over matter...O that moral science were in a fair way of improvement, that men would cease to be wolves to one another, and that human beings would at length learn what they now improperly call humanity (Adams, 1952).

Later, in 1850, when the Industrial Revolution had developed, the Prince Consort of the British Empire spoke about the coming Great Exhibition of 1851, saying, "We are living at a time of most wonderful transition which tends rapidly to accomplish that great end to which all history points--the realization of the unity of mankind. The distances which separated the different nations and parts of the globe are rapidly vanishing before the achievements of modern invention". At almost the same time, however, Thoreau was writing:

> Our inventions are wont to be pretty toys, which distract our attention from serious things. They are but improved means to an unimproved end...We are in great haste to construct a magnetic telegraph from Maine to Texas, but Maine and Texas, it may be, have nothing important to communicate. ("Economy in Walden.)

This kind of debate continues with no little fury today. Works of the late Jacob Bronowski, particularly his Ascent of Man, are but a recent link in the long philosophical chain of belief in the inevitability of progress. Edward Cornish can write that "life is probably far better now for the average person than at any time in the past...This progress suggests what...human intelligence...can accomplish with effort-- and time," (Cornish, 1977). Yet Philip Slater, an articulate social critic, asserts that "the value of technology in increasing human satisfaction remains at best undemonstrated" (Slater, 1976). Indeed, this kind of contention finds clear expression in the conflicting schools of futures thought, to be discussed later.

It is apparent now that the concepts of a malleable future and "progress" underwent a mutual, and indeed, an essential co-evolution. The two concepts provided mutual support and substance to one another. The notion of an undetermined future gave "progress" a context within which to occur. It provided the basis for attempts to determine how "progress" would manifest itself. The social metaphor of "progress" gave meaning to a study

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[5] J.B. Bury, The Idea of Progress (New York: Macmillan, 1932).

of an indeterminate future. It indicated what actions are necessary in the present (and future) to ensure that the potential improvement in the human condition does indeed occur.

By the middle of the eighteenth century, France had become a hotbed of intellectual fascination with the concept of progress. One of the earliest authors to attempt to give form to the progress of the future was a Frenchman named Sebastien Mercier. In 1770 he published a book describing human civilization in the year 2440 A.D. For the motto of his book he adopted the phrase of Leibnitz: "the present is pregnant with the future." A hallmark for the advent of Prophetic fiction, Mercier's The Year 2440 was published anonymously in Amsterdam because of its implied criticism of the French government. The work focused on social and cultural changes and was virtually devoid of scientific advances. In the book, an eighteenth century man wakes from an enchanted sleep to find himself in the 25th century, when the world is made up of nations who live in a peace rarely disturbed by war. Slavery has been abolished. The long rivalry of France and England has been replaced by an indestructible alliance.

Not only did Mercier omit any discussion of scientific advances, but he also seems to have been blind to the possibility that scientific discoverers might themselves "transmute the human situation."

3. Progress, Science, and Technology

Out of the speculations of the eighteenth century, one book still seems to command a good deal of respect among futurists. The Sketch for a Historical Picture of the Progress of the Human Mind, by the Marquis de Condorcet, is considered "one of the greatest classics" of futurism (Cornish, 1977). Written in 1793, it correctly predicted many of the developments of the nineteenth and twentieth centuries. Furthermore, the author is credited with formally originating and using extrapolative prediction, and with pioneering the use of conditional prediction. (If event A occurs then B will follow--see FORECASTING).

In Sketch, Condorcet was predominantly concerned with changes in the social order and with "progress." Unlike Mercier, however, Condorcet was very cognizant of the influence of scientific discovery in effecting such changes. Some of his predictions included the increasing efficiency of farmers due to science, and the widespread use of birth control. Still, there was little attempt to identify the specifics of these scientific advances.

Jules Verne, on the other hand, used his knowledge of the physical sciences as the primary source of his amazing speculations. One of the great technological prophets of the nineteenth century, he authored some sixty books between 1863 and 1903. By the time he had written 20,000 Leagues Under the Sea, in 1870, his reputation was firmly established--he was one of the few authors whose works were read worldwide. Much of his writing was credited with stimulating new scientific exploration and discovery. For example, from his suggestion in From Earth to Moon that a little known metal, aluminum, would make good moonship material, the research began that led to the economical production and subsequent usage of aluminum today.

Although Verne's forecasts of the future were ingenious in terms of their technological speculation, they were limited in other ways. He "peopled his fiction with nineteenth century characters living in a nineteenth century world: he did not undertake the far more complex task of trying to imagine how society as a whole would change as a result of the mechanical wonders he imagined" (Cornish, 1977).

Another major forecast fiction work was published in 1888: Edward Bellamy's Looking Backward: 2000-1887. This novel was a predictive utopia. The narrator, living in Boston in the year 2000, describes the wonders of technology and of social organization: radio, electric lights, indoor air-conditioned malls, clean urban air, full employment, retirement at age forty-five on a good income.

Bellamy found a world audience. Some were enthusiastic--many countries had Bellamy Clubs devoted to promoting his ideas. On the other hand, he prompted hundreds of forecast fictions in alarmed response; people were afraid that the future would work "too well."

Here we are reminded again of the importance of ideas themselves. We can see a pattern emerging whereby the speculations of particular visionaries do much to stimulate the interest and research necessary to bring about the visions they project. Sir

Francis Bacon and his New Atlantis are largely credited for producing the ideas and impetus that led to the first volume of the Encyclopedie in 1751. We have also mentioned one small example, out of many, of Jules Verne's influence.

Apparently there was very little non-fiction futures literature in the nineteenth century. One interesting example, however, is In 100 Years (1892). The author, Frenchman Charles Richet, made statistical projections of population growth around the world, and concluded that Russia and the United States would be the two most powerful countries in 1992. He discussed other things as well, such as the fate of colonial empires. Here we have an excellent example of how a futurist's personal worldview can influence forecasts: "The French would remain in North Africa but Egypt would shake itself free of 'British despotism.'"

It is fairly evident that there was little appreciation of the nature of social systems among the authors of the nineteenth century, as we have already remarked about Verne. "Reviewing the prophets of the past, one finds lacking in almost all of them--at least in their sociological predictions--any notion of how a society hangs together, how its parts are related to one another, which elements are more susceptible to change than others..." (Bell's Introduction to Kahn, 1967).

4. Futures as Mythmaking

A most versatile and influential futurist was H.G. Wells.

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Wells is known, first of all, as a mythmaker. He began writing brilliant scientific thrillers in Britain at a time when the new power of technology was beginning to stir the public imagination. Among the most admired writers of his day, his most famous novel is The War of the Worlds (1898).

Wells did not confine his speculations to works of fiction, although his fictional works are probably the most remembered. In 1901 he wrote Anticipation of the Reaction of Mechanical and Scientific Progress Upon Human Life and Thought, a non-fiction examination of the new trends in society at the time. In Anticipation, Wells analyzed some of the factors producing change in communication, transportation, the size of cities, warfare, etc. Wells was a staunch advocate of the ever-improving human condition--i.e., of the concept of progress. During a lecture given at the Royal Institute in 1902, Wells called for a science of the future that could be at least as credible as geology or archeology. To him, such a science was essential, for "it is into the future we go; tomorrow is the eventful thing for us. There lies all that remains to be felt by us and our children and all that are dear to us."[6]

Wells provided a vital link in the development of the dual concepts of the "future" and "progress." As Cornish puts it,

> In Wells, the study of the future had both an advocate and an exemplar. He moved beyond Jules Verne's interest in the immediate use of potential technology to a concern for its long-term consequences. Verne described submarines and spaceships furnished with Victorian elegance and operated by mid-19th century men in a mid-19th century world;

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[6] H.G. Wells, lecture given at the Royal Institute (1902), quoted in "The Discovery of the Future," Nature, 65: 1684, p. 330.

> Wells recognized clearly that the new technology would change the character of human life and showed how future changes in society might be anticipated by a combination of scientific knowledge and imagination. (Cornish, 1977)

World Wars I and II had an enormous impact on the developing concept of a progressive future as the child of technology. There had always been critics of the notion that improvements in science and technology would inevitably lead to improvement in the human condition. The World Wars, however, dealt a devastating blow to the confidence of the vast majority of society: their faith in inevitable progress was profoundly shaken. Even Wells eventually lost his optimism and in 1945 wrote, "the end of everything we call life is close at hand and cannot be evaded..." A new group of writers drawing from this despondency began to produce anti-utopian or dystopian novels. Of this genre, the best known are Aldous Huxley's Brave New World (1932), Orwell's 1984 (1949), and more recently Kurt Vonnegut's Player Piano (1952) and Anthony Burgess' A Clockwork Orange (1962).

Following World War I, events such as the stock market collapse and the Great Depression did a great deal to propel the new pessimism. Bertrand Russell put into words what was now a widespread belief: "Science has not given men more self-control, more kindness or more power of discounting their passions." Science was now seen as providing men with more and more power to wreak havoc on one another.

In spite of this atmosphere, the predominant view was that the future was still primarily determined by the inevitable forces of evolutionary progress. It is paradoxical that the notion of "free human choice" grew into a new determinism of "inevitable progress." Fate now wears a different mask. No longer are human activities dictated by all-powerful gods, but by an ever-present developmental process that propels human society to greater and greater achievement.

5. Development of a Science of the Future

Future analyzers and planners saw themselves as discerning what the inevitable might be and how it would affect society. Even H.G. Wells, who had called for a "science of the future," felt that even the greatest leaders were the pawns of progress. "I believe that these great men of ours are no more than images and symbols and instruments taken, as it were, haphazard by the incessant and consistent forces behind them; they are the pen nibs Fate has used for her writing, the diamond upon the drill that pierces through the rock." Wells' study of the future was intended to help us prepare for the inevitable, not to alter it.

The Second World War had a profound effect on the futures field. Both France and the U.S. reacted in characteristically different ways to the stresses of the war and in the end produced two approaches to futures thinking. These two approaches would eventually merge into the most prevalent view of futures and planning that exists today.

During the Nazi occupation of France, there emerged a new philosophy to deal with the loss of freedom. Within a country as controlled and repressed as can be imagined, there arose a feeling of fundamental freedom and personal responsibility for every decision and action. This sense of responsibility was strongly individualized. There was no way to excuse one's actions by claiming that an irresistible outside power was responsible. According to this new philosophy, one is always free to make a choice; neither the past, nor individuals or institutions in the present, can take away the fundamental right to decide for oneself. It was Jean-Paul Sartre who gave this philosophy its most powerful voice and coined the name "existentialism" to identify it.

This explicit philosophy had a profound effect on how people viewed the future. The notion of unavoidable futures was receiving some fatal blows. If the past has no hold on us and we are each responsible for our own decisions in the present, then we can choose the direction in which we wish to go. The future is essentially free and unwritten; the past is finished and dead. With such an intellectual climate after the war, the government of France turned to the task of deciding what to do with this unwritten future. The major effort that developed was one of trying to identify desirable (ideal) futures and to determine the best means of attaining them.

A key individual in France's analysis of the future during the 1950s was Gaston Berger. It was in 1957 in Paris that Berger founded a Centre Internationale de Prospective (International Prospective Center). The word "Prospective" was to "denote, first and foremost, a particular attitude of mind toward the problems of the future." "Prospective" was to be the "mirror-image" of "retrospective." Prospective was not intended to be synonymous with forecasting, as Berger considered forecasting to be merely a statement of the extension of present trends. Rather, prospective was to be an orientation to the future in our decision-making of today. "Like Sartre, Berger was a former professor of philosophy and his thinking suggested the marriage of existentialism and planning. 'Prospective' might be viewed as a socialization of existentialism. The reality of choice in creating one's own future was not limited to the individual, but also concerned the nation and all humanity." (Cornish, 1977)

Following the death of Berger in 1960, another Frenchman by the name of Bertrand de Jouvenel stepped in to fill the void. Using funds he received from the Ford Foundation, he began his "Futuribles" project, which consisted of a series of papers by leading scholars concerning what might happen in the future. Eventually a journal of the same name was published and, in 1964, de Jouvenel published his now classic work, The Art of Conjecture. The work provides an epistemology of the study of the future and a general discussion of the possibility and utility of studying the future. It advocates the creation of forums during which the possibilities of the future could be systematically developed and debated.

The Association Internationale Futuribles, which was founded by de Jouvenel and his wife Helene, is still in existence. The work of this organization continues to be an attempt to analyze which assumptions about the future might be true, and how they could be used to achieve an ideal vision.

The European approach to studying the future (typified by the French) has been predominantly philosophical and humanistic. They are concerned with goals and the means of attaining them. This is in contrast to the American science-oriented futurists, who are interested primarily in improving their extrapolative forecasting methodology.

The primary impetus behind the American approach to the future lies in the demand for national security engendered by the Cold War. American futures analysis got its start in the need for perfecting military gaming. The institutes and organizations spawned by that need included the development of the first "think tanks," such as the Rand Corporation and the Institute of Defense Analysis. Indeed, many of the first well-known futurists in the United States got their start doing military forecasts. Herman Kahn is perhaps one of the best known of these, as is his Hudson Institute.

With time, many individuals and institutes began to broaden the scope of their analysis, but the major efforts in American futurism have been directed toward ongoing refinement of the methodology of forecasting techniques. The success of such project-oriented forecasting and research efforts is evidenced by the NASA space program.

The advances made in the development of forecasting techniques in the United States have provided a very potent tool. In relatively recent times, a number of individuals have begun to apply these tools in combination with the more normative approach associated with European futurists. The work by Meadows, et al., entitled Limits to Growth, is a product of this new approach. Additionally, the work by Willis Harman (1976) for Stanford Research Institute attempts to break ground in a similar vein. The great variety of futures work currently taking place in America will be discussed in the next section.

There has, of course, been a constant stream of futurists in the science fiction field who have been dealing with sticky philosophical and social issues as well as the projection of scientific advances. Foremost among these are such names as Issac Asimov, Ray Bradbury, John Brunner, James Blish, and Robert Heinlien.

E. CURRENT SCHOOLS OF FUTURE THOUGHT

1. Differences in Worldviews

The functions of the futures field, as previously identified, have their roots in the historical development of the concepts of the future and of "progress."

The individuals and institutions addressing these functions today can be categorized in many ways--one of the most important distinctions is perhaps the underlying basic assumptions and worldviews that different futurists bring to their study and analysis. Several individuals have attempted to describe and classify the major assumptions and predispositions held by those dealing with the future. Perhaps the most fundamental classification separates those who believe the future is predetermined and those who feel it is not. A somewhat more sophisticated typology might divide attitudes or beliefs about the future into three separate categories. These three models of the future and their accompanying beliefs are described below.

The first model involves a totally deterministic worldview. This viewpoint maintains that the future is predetermined and that nothing we do as individuals can alter or affect the outcome of future events. Or one could argue that everything we do is predetermined and therefore we can not do anything other than what will produce the predetermined future. Such an argument is of course cyclical and useless in terms of predictive ability. Indeed, for the most part someone who believes that the future is predetermined has no interest in the future, believing that he or she will be merely carried by the course of future events.

Therefore the "present" becomes the only thing of importance and one's actions are self-justifying.

A probabilistic view of the future implies that there are a range of alternative futures, some of which are more likely to occur than others. The probability of a particular future is derived from the momentum of decisions and events of the past interacting with present (and) future decisions and actions. To an individual (or society) with this viewpoint, the future is of great interest. If the range of alternative futures and their corresponding probabilities can be identified, then present and future actions can be geared toward increasing the probability of desirable futures. Such future "forecasting" and analysis is particularly important within this paradigm because of the built-in lag-time in any large system between decisions and results. As we have hinted in the previous section, this is the view held by the majority of futurists today.

The third category recognizes an inherent purpose in the fabric of the universe itself. This teleological view of the future sees some great purpose, such as the development of a Greater Intelligence, evolving over time. The future is not strictly predetermined, and the actions of each of us affect the future. The eventual future (end product) itself is not known, but the goal is to preserve the ever-improving process of ongoing development.

The three categories mentioned above represent fundamental beliefs that an individual may hold about the future. (The scheme can, of course, become more complicated by including proposed futures after death, but that area of investigation is not the domain of this work.)

Within these three basic approaches to the future there exists a vast range of images and visions of what the future may bring. There also exist almost as many schemes for classifying and categorizing these visions. Several of these classification schemes offer us useful tools for understanding how individuals see themselves interacting with an emerging future.

While the schemes classify how individuals interact with or perceive the future, they do not all deal with the same interactions. It is possible in some instances to make comparisons and to relate categories to one another. Additionally, it is possible that an individual will make a distinction between his or her image of a societal or global future as opposed to a personal future. An individual concept of the future is almost certain to be affected both by the length of time one is looking ahead and by the number of variables taken into consideration.

Harold Linstone of Portland State University proposes one classification scheme for analyzing the way in which people conceive of and deal with the future (Linstone, 1977). The scheme is divided into four major paradigms. Individuals are seen to operate primarily within one paradigm, but crossover or combining of paradigms is possible under some circumstances.

Discounting of the future is the first paradigm described in Dr. Linstone's scheme. Discounting is commonly done in business and economics and, though rarely perceived, is a common practice in all walks of life. Basically, discounting means that the

TYPE	PHILOSOPHY	TOOLS	CHARACTERISTICS
DISCOUNTERS	Interest only in near term problems		Distinterest in forecasts Improvisation
EXTRAPOLATORS ↗	Future is extension of past	• Trend extrapolation, • Models based on past	Emphasis on data Empiricism Lockean I.S.*
GOAL SETTERS ↙	Idealism Future can be created	• Normative (needs) analyses • Imagination, vision	Emphasis on values Creation of new models Leibnizian I.S.
CYBERNETICISTS ↗↙	Combining of past and future creative approaches (feedback)	• Interaction of exploratory and normative fore-casting • Use of multiple tools	

*I.S. = Inquiring Systems

Figure 2. LINSTONE'S PARADIGMS OF FUTURISTS
(Linstone, 1977)

present is deemed to be more valuable than the future. For example, dollars owned in the present are considered to be worth more than future dollars because of the immediate potential for investing present dollars to make additional money. A common discount rate is ten percent per annum. Hence a dollar would be worth a full dollar today, but worth only ninety cents if it is to be received a year from now. Discounting is actually common to almost all endeavors--as the old adage says, "A bird in the hand is worth two in the bush."

An example of the propensity Americans have for discounting can be seen in our widespread use of the credit card economy. As a nation we seem enamored of the buy now/pay later plan. The use of the goods in the present is deemed more valuable than the eventual cost of the goods, including interest charges, in the future.

Politicians frequently discount programs and projects that will have results beyond their terms in office. Projects and programs receive attention based on the immediacy of deadlines rather than on the intrinsic worth of the projects.

The second paradigm in Linstone's classification describes extrapolators--those individuals who view the future as an extrapolation of the past. Such a vision of the future is extremely popular because it is based on empirical data--known facts about trends in the past. This base line data is used to project what the future will bring. This approach appeals to our technological science-oriented culture, which so highly values "solid data" in arriving at conclusions. Of course, there are several pitfalls inherent in using this "vision" of the future. Because of the emphasis on data, only those variables with available data are used in the analysis. This drastically reduces the information used in developing trend extrapolations. Many variables with important impact on the nature of the future are not considered because there is no data available, or the data itself is "messy." Unforeseen or "wild card" factors may also affect future trends. Additionally, the choice of which trends to extrapolate can drastically affect the overall image of the future "produced."

Discounting of the past may often interact with the extrapolation paradigm by limiting the analysis of trend data to only the most recent past. This greatly restricts the ability to perceive long-term trends. Drawbacks such as this require serious consideration when trend extrapolation is undertaken. One possible solution to the problem is to extrapolate various alternative futures using several variables and empirical as well as non-empirical input. One future image classification scheme using just such an approach will be discussed later.

Goal setters represent the third paradigm in Linstone's classification. This group is represented by individuals who feel a strong preference for a normative analysis (see normative forecasting) of the future and its constituent value base. The images of the future they construct are not totally derived from past data, and as such they are not extrapolations of what might be, but are visions of what the forecaster would like the future to be. Goal setters are invariably visionaries who perceive the necessity of a new moral order and are concerned with the means of reaching that end, as opposed to those concerned with analyzing our social direction and trying to prepare for what is to come.

Cyberneticists represent the last major category in the Linstone scheme. Individuals in this group neither see the future as some single desired ideal state nor as the inevitable outcome of some present trend. Their vision of the future includes an acceptance of the constraints that past trends place on the direction of the future, as well as an acceptance of the ongoing changes that will affect and alter those directions. The cyberneticists as a result foresee a range of possible futures, each of which undergoes constant alteration as a result

TYPE ↓		FUNCTIONAL ORGANIZATIONS Business Military	ARCHITECTS TECHNOLOGISTS ↓	SOCIOLOGISTS THEOLOGIANS ↓	ECONOMISTS ↓	WRITERS ARTISTS ↓
DISCOUNTERS	MOST OF THE PUBLIC	Unsophisticated businesses				
EXTRAPOLATORS	POPULARIZERS: Toffler, Jungk ENTREPRENEURS: Cetron, Gordon	Conventional business planners Utility industry Military agencies	Most technologists Lenz	Bell Gilfillan ← Kahn McHale	Most economists	"Year 2000" (Kahn-Wiener)
GOAL SETTERS		Creative marketing organizations Drucker Bennis Harman De Gaulle	Dubos Gabor Fuller Soleri Spilhaus	de Chardin Galtung Reich Skinner Saint Simon	Galbraith Theobald	Burgess Bradbury Capek Clarke Kafka Orwell most science fiction
CYBERNETICISTS		Defense: RAND systems analysis groups	Ayres Forrester Jantsch → Martino Turoff Gordon	← Dalkey Michael Ozbekhan	Boulding Leontief	"Limits to Growth" De Jouvenel

Figure 3. LINSTONE'S CLASSIFICATION SYSTEM FOR FUTURISTS (Linstone, 1977)

It must be emphasized that the distinction between the various paradigms is not always clear-cut, and individuals frequently operate in more than one mode. The categories do offer a means of analyzing different approaches to the future, and thus provide a basis for the comparison of several other future images classification schemes to follow. Representative examples of various categories envisioned by Linstone are presented in Figure 3, and examples of their work are referenced in the bibliography.

Other classification schemes deal with the structure and focus of the institutions themselves. Roy Amara (1974), for example, has identified four institutional "types," and associated them with the previously identified functions or roles. (See Figure 4.)

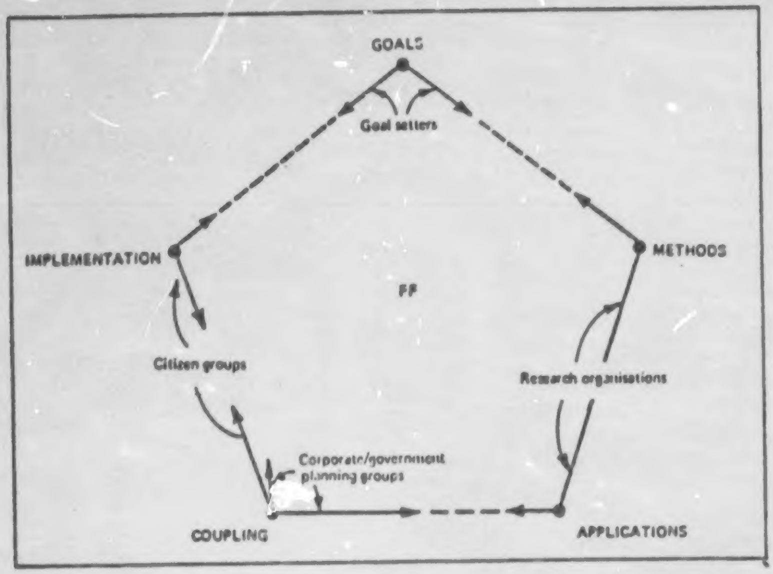

Figure 4. OVERLAY OF INSTITUTIONAL FORMS ON BASIC FUNCTION DIAGRAM

The existing institutions are categorised into four major groups

- *Goal setters* or "image generators" (50-60*) including particularly creative individuals contributing to the FF largely "on their own." They may be found in universities, research organisations, or elsewhere. Many of them would be identified as visionaries; some might not even recognise that they are members of the futures community; others might pursue futures only as a part-time activity. For each of these reasons, this is the fuzziest--and yet the most important--category, for it is from this sector that most of the highly imaginative image-oriented thinking emanates.
- *Research organisations* (25-30) including most independent organisations engaged in futures research: profit or non-profit, completely or partially (but not peripherally) dedicated, large or small. They may be found within universities, or elsewhere in the public or private sector. Although the variety of sub-forms is still large, it is by no means as heterogeneous a group as the others. In fact, this group represents the most highly developed of futures institutional forms. Functionally, the emphasis of the group is on the applications-oriented activities, and usually (but not always) on methodology.
- *Corporate or government planning groups* (50) including most futures-oriented units (sometimes consisting of single individuals) that have evolved from related tactical planning, "programming-planning-budgeting" corporate development, or technological forecasting activities. Normally, such units are not directly involved in research themselves. Instead they serve as interfaces between the world outside and internal organisation operating units. The focus is thus clearly on coupling activities.
- *Citizen groups* (10-25) including the most dynamic--and perhaps from a futures standpoint the most unorthodox--members. As noted earlier, the varied "tomorrow/2000/goals" movements might not, at first, be included as part of the FF. Yet is is very likely that the success of the FF depends critically on the effectiveness with which research results can ultimately be coupled to, and used by, large segments of the interested public.

*Best estimates of the number of institutions in the USA included in each grouping. However--to avoid misrepresentation due to faulty data and misperceived emphases--no attempt is made to classify particular individuals, organisations, or groups.

[Amara, 1974]

2. Alternative Future Images

The previous classiciations are predominantly concerned with the context within which individuals or institutions view the future. While the different paradigms strongly influence the specific future images, they do not actually describe specific visions of the future. The Alternative Futures for Environmental Policy Planning: 1975-2000, produced by Stanford Research Institute (Elgin, et al., 1975) is representative of a type of future images classification system that identifies actual future scenarios perceived to be possible. The development of this classification included the use of extrapolation and scenario writing techniques. (See FORECASTING METHODS, in FORECASTING, PLANNING, AND POLICY FORMATION section of this Sourcebook.)

In effect, the development of these alternative futures represents the extrapolation of several trends or potential paths in the future, and the integration of the thoughts and observations of both future visionaries (goal setters) and cyberneticists. The development of scenarios is perceived as a tool for exploring the uncertainty of the future so that decisions can be considered in light of different future contexts. The ability to consider a range of future potentialities helps prepare us to deal with a changing future, and with change in general.

The SRI study was undertaken with a conscious effort to include those variables that normally elude easy quantification. While the SRI study identifies ten alternative futures, these futures actually represent subcategories of three major future themes. The first of these represents the success of the industrial paradigm. "In spite of problems in the U.S. and the world, societies continue to prosper and grow up with political, social, economic, and environmental problems being eventually solved without significant institutional or value changes required. This scenario or future image might be viewed as the 'success of technological society'" (Elgin, et al., 1975).

The second major theme, "industrial failure," is the mirror opposite of the industrial success scenario. The same institutions and values prevail but they do not enable society to weather the upcoming period of trouble. Resources are insufficient and technology is unable to fill the gap; the industrial paradigm continues to operate, but less efficiently and with increasing amounts of misery and unhappiness. In spite of this, the institutions and values remain substantially unchanged.

The third theme represents an "industrial transformation" reminiscent of the emergence of the Industrial Revolution. The industrial paradigm itself is altered over a period of time and is in effect replaced by a lifestyle characterized by voluntary simplicity. The negative aspects of the industrial paradigm are seen to outweigh its potential for further success; a new mode of living emerges in which maximum human happiness is combined with a concept of minimum consumption. In this paradigm transitional problems are overcome and the result is "new social and economic institutions incorporating the principles of harmony between human activity and the natural environment."

The ten future scenarios of the study are variations on these three basic themes, presenting a mixed bag of alternatives.

The four major driving trends that form the structure of each theme are Energy, Climate, Values, and Food.

Herman Kahn, one of the better known modern futurists, in his book The Next 200 Years (1976), describes yet another set of future images. In his classification scheme, Kahn breaks down the current concepts of the future into four major categories. The basic common denominator is the success (or failure) of the industrial/technological paradigm. In this sense it resembles the SRI classification system. The SRI study, however, presented a third alternative--that of "post industrial transformation." The two additional Kahn classifications represent mitigating positions of the two extremes (success or failure). The four categories are labeled (1) Convinced Neo-Malthusian; (2) Guarded Pessimist; (3) Guarded Optimist; and (4) Technology and Growth Enthusiast. Kahn is one of the more staunch supporters of the "Technology and Growth Enthusiast" image of the future. These future images are summarized below.

Under Linstone's classification system, Kahn's generally optimistic viewpoint establishes him as an extrapolator with an essentially utopian viewpoint--the future that will result as a natural consequence of existing trends will be an extremely good one. In the same vein, Kahn's "Neo-Malthusian" viewpoint is an extrapolation of present (but different) trends and is dystopian in nature. The two intermediate positions could be viewed as variations on the extrapolation theme, with at least a guarded use of the cybernetic approach of dealing with the future. Please refer to Figure 5 for a description of Kahn's (1976) categories of futurists.

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	Convinced Neo-Malthusian	Guarded Pessimist	Guarded Optimist	Techonology and Growth Enthusiast
1. BASIC WORLD MODEL	*Finite pie.* Most global nonrenewable resources can be estimated accurately enough (within a factor of 5) to demonstrate the reality of the running-out phenomenon. Whatever amounts of these resources are consumed will forever be denied to others. Current estimates show we will be running out of many critical resources in the next 50 years. The existing remainder of the pie must be shared more fairly among the nations of the world and between this generation and those to follow. Because the pie shrinks over time, any economic growth that makes the rich richer can only make the poor poorer.	*Uncertain pie.* The future supply and value of both old and new materials are necessarily uncertain. Past projections of the future availability of materials usually have been gross underestimates. One can concede this could happen again, but current estimates seem relatively reliable. Current exponential growth clearly risks an early exhaustion of some critical materials. Prudence requires immediate conservation of remaining resources. Excessive conservation poses small risks while excessive consumption would be tragic.	*Growing pie.* Past technological and economic progress suggests that increasing current production is likely to increase further the potential for greater production and that progress in one region encourages similar developments everywhere. Thus as the rich get richer, the poor also benefit. Higher consumption in the developed world tends to benefit all countries. Excessive caution tends to maintain excessive poverty. Some caution is necessary in selected areas, but both the "least risk" and the "best bet" paths require continued and rapid technological and economic development.	*Unlimited pie.* The important resources are capital, technology and educated people. The greater these resources, the greater the potential for even more. There is no persuasive evidence that any meaningful limits to growth are in sight—or are desirable—except for population growth in some LDC's. If any very long-term limits set by a "finite earth" really exist, they can be offset by the vast extraterrestrial resources and areas that will become available soon. Man has always risen to the occasion and will do so in the future despite dire predictions from the perennial doomsayers who have always been scandalously wrong.
10. LONG-RANGE OUTLOOK	*Bleak and desperate.* Unless revolutionary changes are soon made, the 21st century will see the greatest catastrophe of history resulting from large-scale damage to the environment and to the ecology of many areas. Billions will die of hunger, pollution and/or wars over shrinking resources. Other billions will have to be oppressed by harsh authoritarian governments. Grave and even draconian measures are justified *now* to alleviate the extent and intensity of future collapse.	*Contingent disaster.* Although it is not possible to predict which disaster is most imminent, many possibilities exist even if we are careful and prudent today. Unless we take drastic actions soon, mankind may be overwhelmed by climate changes, destruction of ocean ecology, excessive pollution or other disasters. Society must not challenge the environment and ecology so recklessly any more. We must also manage our resources and population more prudently—at least after the next disaster, if not before.	*Contingent success.* The 21st century is likely to bring a worldwide postindustrial economy in which most problems of poverty will be largely solved or alleviated. Most misery will derive from the anxieties and ambiguities of relative wealth and luxury. Some suffering and damage will mark the historical transition to a materially abundant life, but the ultimate prospect is far superior to a world of poverty and scarcity.	*High optimism and confidence.* We cannot know mankind's ultimate goals, but they include a solar civilization and a utopian notion for the quality of life on earth. The potentialities of modern technology and economic progress are just beginning to be visualized. Dangers exist, but they always have and always will. There is no need for faint heart. Man should face the future boldly and openly because the future is his to determine—and to enjoy.

Figure 5. KAHN'S CLASSIFICATION SCHEME FOR FUTURISTS

Another study at the Stanford Research Institute, directed by Willis W. Harman, resulted in a report entitled the Changing Images of Man (1977). Harman and his group of researchers produced an alternative futures tree, which is illustrated in Figure 6.

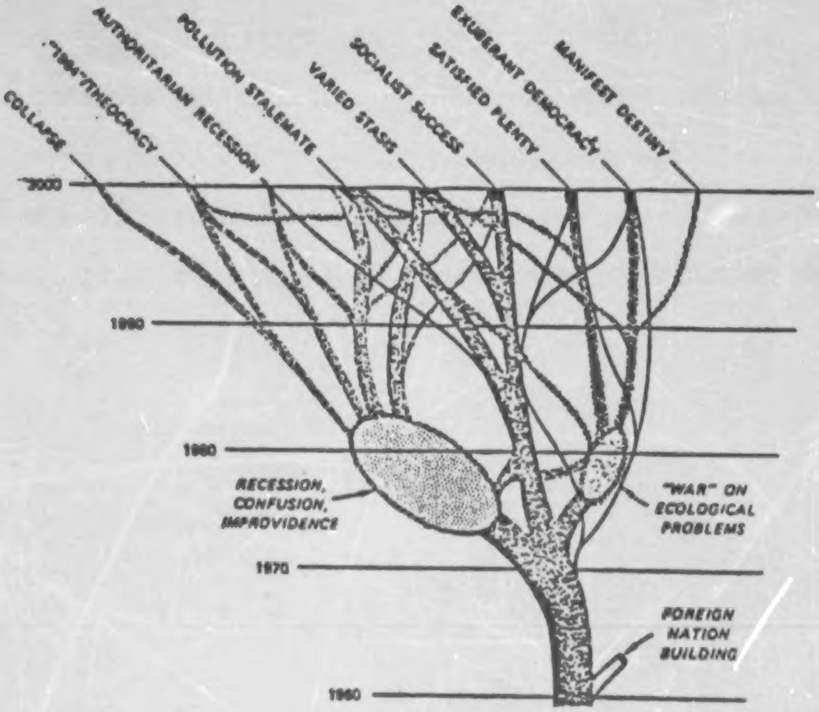
COLLAPSE
"1984"/THEOCRACY
AUTHORITARIAN RECESSION
POLLUTION STALEMATE
VARIED STASIS
SOCIALIST SUCCESS
SATISFIED PLENTY
EXUBERANT DEMOCRACY
MANIFEST DESTINY
2000
1990
1980
1970
1960
RECESSION, CONFUSION, IMPROVIDENCE
"WAR" ON ECOLOGICAL PROBLEMS
FOREIGN NATION BUILDING

Figure 6.. AN ALTERNATIVE FUTURES TREE (Harman, 1977)

The three axes of the tree represent (1) time (1965-1995); (2) society's ability to deal with the problems it faces (ranging from apt and energetic to inept and lacking in vigor); and (3) the degree of openness, mutual trust, and individual liberty allowed. The futures tree developed at SRI illustrates the recognition of a range of possible futures, a smaller group of potential futures, and an even smaller group of probable futures. Within that smaller group there still remains a diverse set of futures, which largely represent branchings off several major themes.

Harman emerges primarily as a "Goal Setter" in his description (and support) of the central theme, which he labels "successful transformation to a transindustrial society." The transindustrial transformation is similar to the previously described transformation to voluntary simplicity (Elgin, 1975). It involves a distinct shift away from the values and institutions characterized by the industrial paradigm.

Another major trunk of the SRI futures tree represents a failure of the attempt at transformation. Numerous branchings emerge from all these trunks and with varying degrees of probability can place society in almost any of the defined end states.

From the structure of the future tree it seems obvious that Harman and his colleagues feel that the trunk of transindustrial transformation provides the highest probability of emerging in relatively good shape from our current megacrisis. As Harman states, "The crucial gap is not between generations, nor between liberals and conservatives, but between those who anticipate a continuation of present trends and those who insist that a drastic change must occur."

Bernard Gendron, in Techology and the Human Condition, proposes his own variation of the three-pronged futures tree. Under the classification of utopian and dystopian features, Gendron basically describes what we have already respectively termed success and failure of the industrial paradigm.

The premises inherent in Gendron's utopian view are as follows:

Premise 1: We are currently undergoing a postindustrial revolution in technology.

Premise 2: In the postindustrial age, technological growth will be sustained.

Premise 3: In the postindustrial age, continued technological growth will lead to the elimination of economic scarcity.

Premise 4: The elimination of economic scarcity will lead to the elimination of every major social evil.

The dystopian viewpoint ascribes the major deterioration of society to the negative effects of technology and the industrial paradigm.

The third future path in Gendron's tree is reminiscent of the previously mentioned SRI categories in that it involves a transformation of the actual value base and supporting institutions. Gendron's "socialist image" of the future (as he terms it) differs in some important respects from the transformation scenarios in other studies, however. In the socialist view, Gendron describes a growing technology that is still seen as a crucial element in eliminating social problems. This is in contrast to a move toward a reduction of dependence on a growing technology in the other transformation classifications. The crucial difference between the utopian and socialist view of the future is in who controls the technology--with a realization that technology itself is insufficient to solve social problems.

Like the dystopians, the socialists believe that technology is producing more problems than it is solving; but unlike dystopians, they feel that this is the fault of the capitalist management system, rather than an inherent danger in rapidly gowing large-scale technology.

In contrast to this analysis of the future is the image of "hard" and "solf" paths of technology into the future described by Amory Lovins (Lovins, 1977). Lovins essentially draws a distinction between futures in which technology (particularly energy technology) is centralized, complex, capital-intensive, and overmatched to its end use, and technology that is matched in complexity to its intended use. Lovins visualizes, in addition to mammoth savings of energy due to increased efficiency, a decrease in the environmental and social impact of technology by following the soft path.

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SUBJECT MATTER/ PROCESS ARRAY

A. INTRODUCTION

The Curriculum Map, or Subject Matter/Cultural Process Matrix (Figure 1) is a morphological construction; i.e., the headings listed along the side and across the top attempt to be all-inclusive. Theoretically, this affords every possible combination or interaction to be examined. The headings listed as ENERGY RELATED SUBJECT MATTER AREAS were designed to follow a pattern from broad and general to specific; for example, Natural Resource Bases are considered broadly, while Energy Utilization is addressed specifically; Cultural development is a background for social development, which is in turn a background for Individual development. In this manner, each grouping of subject matter areas form the context for the ones that follow. These energy-oriented, related headings originated from an analysis of the natural and social sciences. Some of the entries came from specific topics treated in textbooks and curricula; others were included to ensure a comprehensive array consistent with design principles of the EETTM; i.e., individual to social and examining energy in terms of larger cultural processes.

The major processes of culture fall into 3 areas: PROBLEM SOLVING, DECISION MAKING, and ENVALUATION. PROBLEM SOLVING can be initiated for a variety of reasons, such as the presence or awareness of an obvious problematic situation or the realization of or desire for the improvement of a non-problematic situation. One of the most important steps for the problem solver or problem solving body to implement is the selection of a problem solving routine appropriate for the situation. The nature of the problem creates or implies certain determinants, which become constraints upon the selection of an appropriate routine for solving the problem. Some of the determinants/constraints are as follows:

- the number of factors imposed upon judging a "best" solution;
- the number of and range of impacts and controls inherent in different solutions;
- the number of persons and/or groups effected or involved;
- the number of "proximate" or equally attractive solutions; and
- the state of the overall systems readiness to receive a solution.

Four other factors influence the selection of an appropriate problem solving routine:

- the interest (motives, attitudes, intentions) of the problem solver or problem solving body;
- the developmental needs of the problem solver, or problem solving needs;
- the ideologies inherently expressed by the problem solver in selection of the routine (Totalitarian--set viewpoint, includes altruism; Gnostic--elitist, searches for truth and ideals, private; Experiential--explores all interesting options; Individualist--self determined);
- The referential values to be expressed by the problem solver (physical, social, cultural, habitat).

Figure 1.

ENERGY/ENVIRONMENTAL SUBJECT MATTER/CULTURAL PROCESS MATRIX

CULTURAL PROCESSES	PROBLEM SOLVING				DECISION MAKING		EVALUATION					
ENERGY-RELATED SUBJECT MATTER AREAS	ARTISTIC	CRAFTS-RELATED	TECHNICAL	PARADIGMATIC	SCIENTIFIC	MANAGEMENT	CURRENT EXISTING VALUES	IDENTITY CHANGE	ASPIRATIONS	JUDGMENT & ASSESSMENT	VALUES CLARIFICATION	WORLDVIEW
I. CULTURAL DEVELOPMENT & NATURAL RESOURCES												
A. Natural Resource Bases 1. dynamic characteristics 2. adverse impact												
B. Human Evolution & Adaptation: Psycho-Social Phenomena 1. cognition 2. mental states 3. communication & information transfer												
C. Evolution of Cultural Form 1. creation myths & cosmology 2. bio-geography 3. socio-biology												
D. Cultural Forms and Changing Resource Bases 1. hunter-gather/nomadic 2. agrarian 3. advanced agrarian 4. industrial 5. post-industrial												
E. Cultural Adaptations & Changing Resource Bases 1. adaptation to external forces 2. adaptation to internal forces												
II. CONTEMPORARY SOCIAL SYSTEM REQUIREMENTS												
A. Human Needs (Individual & Social) 1. shelter 2. organizations 3. creativity & recreation 4. food 5. communications 6. physical protection 7. apparel & grooming 8. curiosity & knowledge 9. spiritual 10. life cycle												
B. Socially Derived Needs 1. energy & other natural resources 2. energy & natural resources delivery systems 3. agriculture 4. transportation 5. production & maintenance of goods 6. services 7. currencies 8. information												

III. ENERGY BASIS OF HUMANITY & NATURE												
A. Physical/Chemical Properties 1. types 2. states 3. forms 4. sources 5. conversion												
B. Biological (Bio-) Energetics 1. metabolism 2. food webs 3. succession 4. adaptation 5. evolution 6. extinction												
C. Macro-Energy Systems Behavior 1. depicting energy systems 2. systems principles 3. limitations 4. systemic evolution												
IV. ENERGY & CULTURE												
A. Energy & Social Dynamics 1. energy legislation, politics & policy formation 2. energy forecasts & future scenarios 3. economics of energy delivery systems 4. organizational & institutional construction												
B. Energy & Technology 1. discoveries of energy resources 2. dynamics of energy resources 3. history of energy technology												
C. Energy Dynamics & Community Form 1. rural 2. urban 3. regional 4. national 5. global												
D. Energy & Citizenship (Aggregate) 1. mass consumer decisions 2. social activities & decisions 3. political activities & processes 4. comparative social & cultural values and worldviews												
E. Energy & Citizenship (Individual) 1. individual consumer decisions 2. individual activities & decisions 3. political activities & processes 4. individual worldviews & values 5. energy, jobs & careers												
V. ENERGY & WELL-BEING												
A. Energy, Technology & Health 1. risks & hazards to individuals 2. risks & hazards to society												
B. Energy Utilization 1. safety to individuals 2. safety to society 3. lifestyles & energy factors												

The four major problem solving routines and some of their characteristics are:

- artistic approach: search for form and protocol with little or no limitation on media, tools, or procedures;
- craftsperson approach: search for form which expresses the embodiment of a style and/or tradition. Varying crafts have limitations on acceptable media, tools, and procedures;
- technical approach: search for methods and valid routines, experimentally applied science, fewer limitations on media and tools but stricter limitations on procedures;
- paradigmatic approach: search for verities and constancy; concerned with rules and truth, redirect and control. Little restriction on media and tools. Radical changes in procedures can lead to a major shift in the entire paradigm.

The DECISION MAKING process is concerned with selecting the "best" from a variety of options. Evaluation of these options for the purposes of decision making is performed in two basic modes: Scientific and Management. Scientific decision making is characterized by a model that:

- resolves choices in matters of fact or truth;
- guides conduct of research;
- guides scientist on choices for conducting research;
- deals with the verities of all systems (human and natural).

Figure 2 illustrates the general stages of scientific decision making.

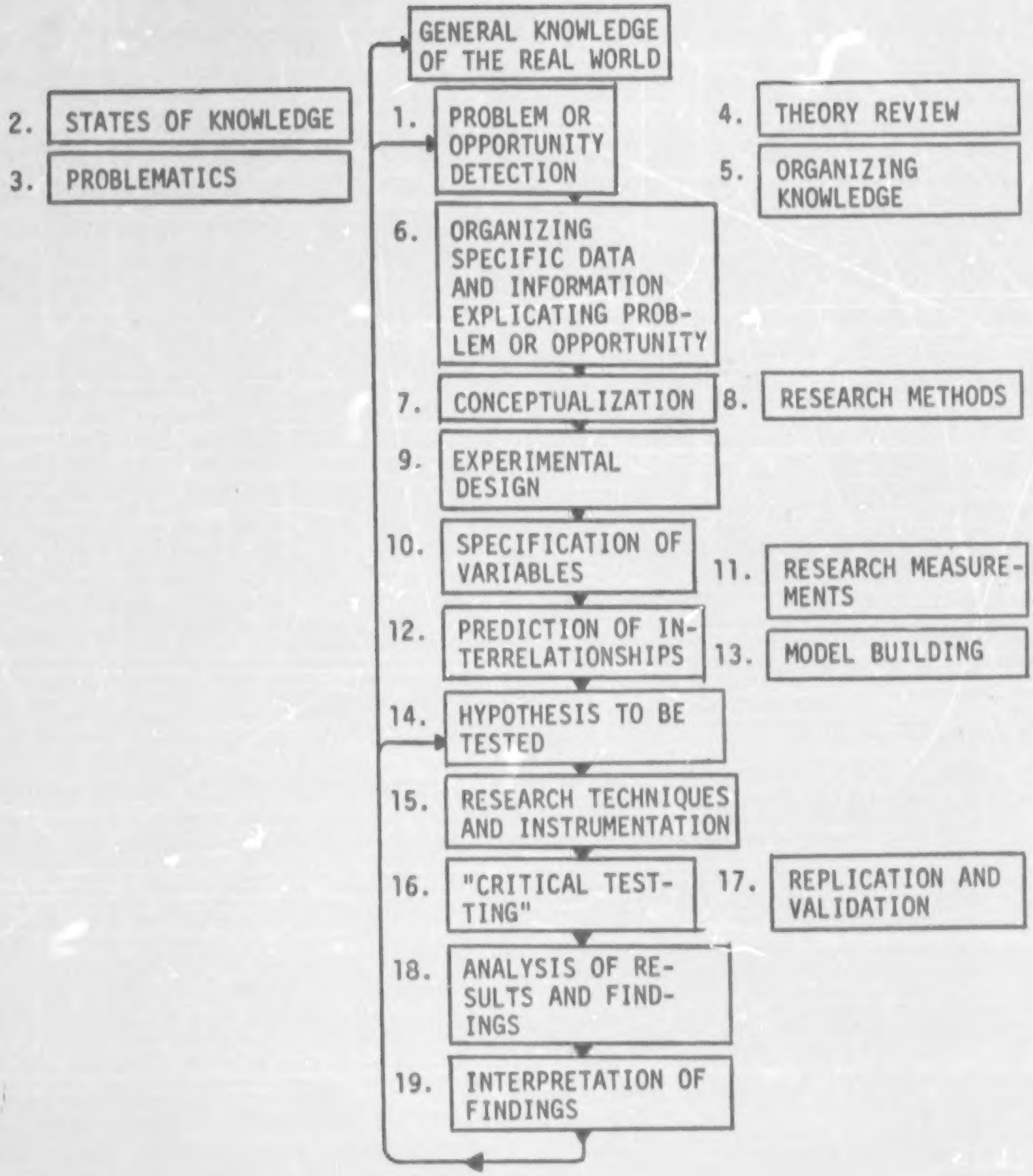
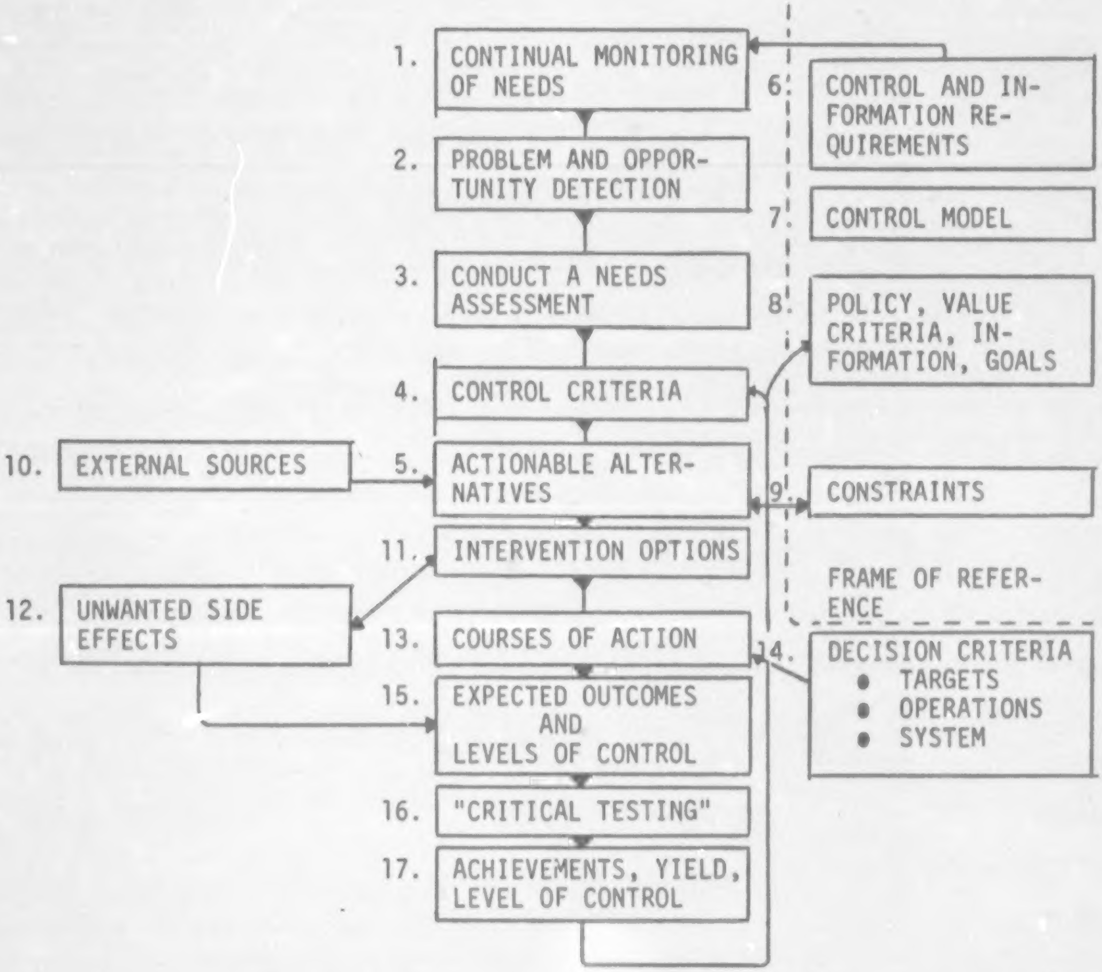

GENERAL KNOWLEDGE OF THE REAL WORLD
2. STATES OF KNOWLEDGE
3. PROBLEMATICS
1. PROBLEM OR OPPORTUNITY DETECTION
4. THEORY REVIEW
5. ORGANIZING KNOWLEDGE
6. ORGANIZING SPECIFIC DATA AND INFORMATION EXPLICATING PROBLEM OR OPPORTUNITY
7. CONCEPTUALIZATION
8. RESEARCH METHODS
9. EXPERIMENTAL DESIGN
10. SPECIFICATION OF VARIABLES
11. RESEARCH MEASUREMENTS
12. PREDICTION OF INTERRELATIONSHIPS
13. MODEL BUILDING
14. HYPOTHESIS TO BE TESTED
15. RESEARCH TECHNIQUES AND INSTRUMENTATION
16. "CRITICAL TESTTING"
17. REPLICATION AND VALIDATION
18. ANALYSIS OF RESULTS AND FINDINGS
19. INTERPRETATION OF FINDINGS

Figure 2. THE SCIENTIFIC DECISION MAKING MODEL

Management decision making is characterized by a model that:

- sets forth courses of action;
- sets forth reasons for accepting or rejecting courses of action;
- deals with options for improving control of human sustems.

Figure 3 illustrates the general stages of the management decision-making approach.



1. CONTINUAL MONITORING OF NEEDS
2. PROBLEM AND OPPORTUNITY DETECTION
3. CONDUCT A NEEDS ASSESSMENT
4. CONTROL CRITERIA
5. ACTIONABLE ALTERNATIVES
6. CONTROL AND INFORMATION REQUIREMENTS
7. CONTROL MODEL
8. POLICY, VALUE CRITERIA, INFORMATION, GOALS
9. CONSTRAINTS
10. EXTERNAL SOURCES
11. INTERVENTION OPTIONS
12. UNWANTED SIDE EFFECTS
13. COURSES OF ACTION
14. DECISION CRITERIA
● TARGETS
● OPERATIONS
● SYSTEM
15. EXPECTED OUTCOMES AND LEVELS OF CONTROL
16. "CRITICAL TESTING"
17. ACHIEVEMENTS, YIELD, LEVEL OF CONTROL
FRAME OF REFERENCE

Figure 3. THE MANAGEMENT DECISION MAKING MODEL

An important distinction to be noted by comparing Figures 2 and 3 is the inclusion of an "external" frame of reference in the management decision making model. As opposed to the scientific model, the management model introduces knowledge, attitudes, and values from the whole society.

In Environmental Education, defined as the "interaction of systems of humanity and nature in a values laden context," the decision making processes are necessarily complex. Complex decision making is a unique class of decision making. A complex decision making model must:

- be based on systemic, holistic methods for dealing with complex issues;
- utilize data, organizational methods that enhance human perception;
- provide the basis for the disciplined development of new knowledge and more comprehensive and integrated strategies;
- have the ability to adapt and change itself;
- enable users to explore and mediate conflicting dimensions of public/private, individual/social, natural/humanity constructed systems;
- recognize the utility of intuitive methods in addition to rationale and scientific methods;
- generate a variety of implementation strategies;
- generate appropriate decision criteria for evaluating alternative solutions;
- enable users to articulate and explore the value dimensions of the decision making process.

ENVALUATION is the process of acquiring, developing, and modifying values. A "value" implies an importance within multiple, individual, group, or institutional frames of reference and is derived through an exchange between entities in which some action is necessarily involved. In this sense, "value" can be seen as analogous to currency. Some characteristics of the ENVALUATION process are:

- the discrimination of differences between self and others;
- the development of aspirations and commitments to become like the others;
- some physical action--constrained by the scope and direction of aspirations and the strength of commitment;
- value clarification--analysis and judgment of the personal "cost" of the action and the resulting "benefit" or degree of satisfaction;
- resolution of the discrepancy between the "value" derived through value clarification and the "anticipated" or projected value;
- estimation of effects on the "self" caused by an acceptance of the various alternative resolutions;
- comparison of alternative effects on the self with the existing overall values profile;
- selection of an alternative which results in a reduction of internal dissonance.

Figure 4 illustrates the stages of the ENVALUATION process. This model is generally applicable to the envaluation process between combinations of persons, groups, and institutions.

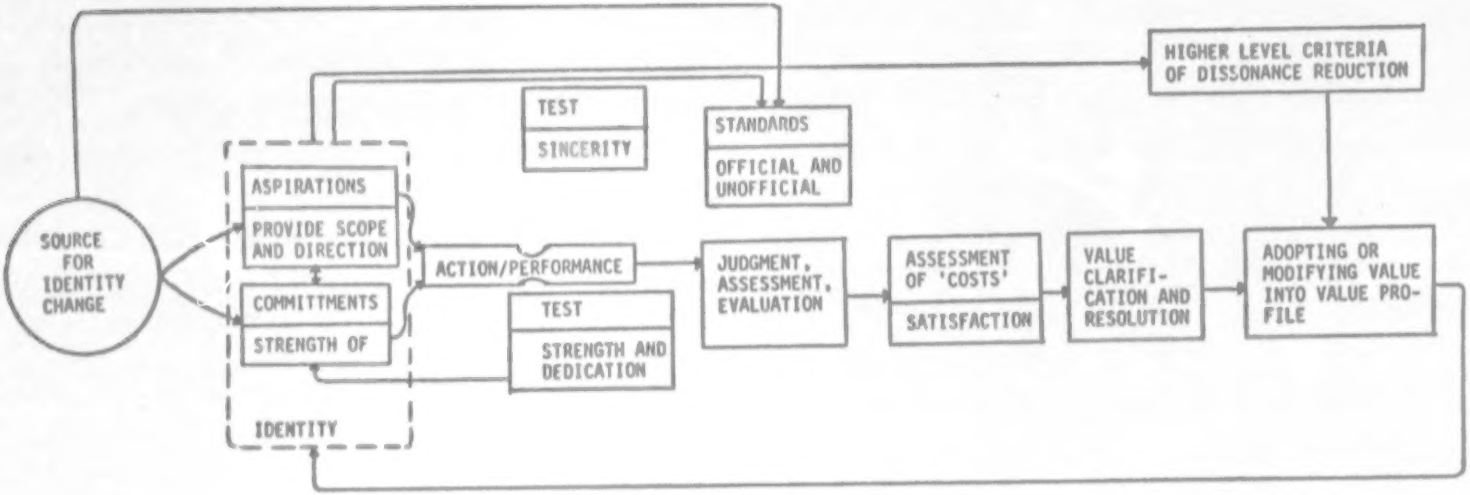

HIGHER LEVEL CRITERIA OF DISSONANCE REDUCTION
TEST
SINCERITY
STANDARDS
OFFICIAL AND UNOFFICIAL
SOURCE FOR IDENTITY CHANGE
ASPIRATIONS
PROVIDE SCOPE AND DIRECTION
COMMITTMENTS
STRENGTH OF
IDENTITY
ACTION/PERFORMANCE
TEST
STRENGTH AND DEDICATION
JUDGMENT, ASSESSMENT, EVALUATION
ASSESSMENT OF 'COSTS'
SATISFACTION
VALUE CLARIFI- CATION AND RESOLUTION
ADOPTING OR MODIFYING VALUE INTO VALUE PRO- FILE

FIGURE 4. THE ENVALUATION PROCESS

Located within the cells formed by the interactions of the subject matter areas and cultural processes presented in Figure 2 and described above should be:

- EE concepts, principles
- resources for further study that explicate or are representative of concepts, principles, identified;
- competence statements (which characterize environmentally literate, competent, and aware citizen).

For example, in the cell formed by the intersection of ENERGY and CULTURE/Energy and Social Dynamics and PROBLEM SOLVING/Paradigmatic one might find information such as the following:[1]

CONCEPTS:

- appropriate technology;
- driving functions;
- quality of life;
- free work of nature.

RESOURCES

- Howard T. and Elisabeth C. Odum, Energy Basis for Man and Nature (New York: McGraw-Hill Book Co., 1976);
- E. F. Schumacher, Small is Beautiful: Economics as if People Mattered (New York: Harper and Row, 1973);
- Barry Commoner, The Poverty of Power: Energy and the Economic Crisis (New York: Alfred A. Knopf, 1976);
- Raymond F. Dasmann, The Conservation Alternative (New York: John Wiley and Sons, Inc., 1975).

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[1] In an attempt to assess the utility of the Curriculum Map and to provide "seed" material for potential users, staff members placed all concepts, principles, etc. from four energy-focused teacher training modules on the Map. The sample cell material listed above is representative of this exercise.

COMPETENCIES:

- Be familiar with some forms of land abuse and misuse caused by resource exploitation and urban and agricultural encroachment;
- Appreciate the importance of considering tradeoffs between our desires for quality of life and the resource capabilities of our natural environment;
- Be familiar with the major types of landforms and the "free work" these landforms provide;
- Be able to characterize some "new" economic models.

B. UTILITY OF THE CURRICULUM MAP

In adhering to the relationships organized as the protocol for developing holistic EE instructional materials, the Curriculum Map component can be used in a variety of ways, depending upon where one enters the protocol process. The Curriculum Map, in presenting a comprehensive array of energy-oriented subject matter areas and cultural processes at a similar level of resolution, enables curriculum developers and teachers to approach the map from two directions. Regardless of where they enter the protocol process, curriculum developers can use the Curriculum Map to help articulate the focus and scope of new content ideas and/or to check the comprehensibility of existent curricula. In articulating new ideas, the Map and materials already identified within cells can help teachers recognize the infinite variety of ways to express or explore dimensions of energy/environmental problems and issues. Or, in placing in the cells the concepts, principles, competence statements, and resources comprising existent curricula, teachers can assess the comprehensibility of their materials and can outline additional content areas to be incorporated or developed into new modules, units, case studies, etc.

In summary, the subject Matter/Cultural Process Matrix, or Curriculum Map, can be used to:

- ensure breadth and depth in designing Energy/Environmental curriculum content;
- provide a broad spectrum of SUBJECT MATTERS and PROCESSES that enable designers to address, to recognize, or to incorporate content from a wide variety of disciplines into the fabric of environmental education;
- allow developers or teachers in specific disciplines to find or locate themselves within the scope of EE content;
- demonstrate the interdisciplinary nature of environmental education by illustrating the essential contributions of the natural and social sciences;
- demonstrate the breadth or range of topics and processes that enable designers to address Energy/Environmental education at the level of environmental issues.

GLOSSARY

ABATEMENT: The act of reducing the degree or intensity of pollution.

ABSORPTION: The penetration of a substance into or through another.

ACCLIMATION: The physiological and behavioral adjustments of an organism to changes in its immediate environment.

ACCLIMATIZATION: The adaptation of a particular species over several generations to a marked change in the environment.

ACCULTURATION: The process of external change imposed on a population, with loss of traditional social and cultural institutions.

ACID MINE DRAINAGE: Seepage water that combines with acid-forming ions in mine ores, such as chlorides and sulfides, to produce an acid solution. This acid often finds its way into local streams. Sometimes the pH is as low as 3.5, which is lethal to most stream organisms.

ACID RAIN: The popular name for sulfuric acid aerosols heavy enough to be washed out of the atmosphere in rainstorms. The sulfuric acid enters the atmosphere as sulfate ions derived from combustion of sulfur-rich fuels.

ACRE FOOT: The amount of water needed to cover 1 acre with 1 foot of water. It is equivalent to 325,872 gallons or 43,560 cubic feet of water.

ACTIVATED SLUDGE: Sludge that has been aerated and subjected to bacterial action. It is used to remove organic matter from sewage.

ADAPTATION: A change in structure or habit of an organism that produces better adjustment to the environment.

ADAPTIVE: Behavior that contributes to the continuing survival and flexibility of a system; may continue or change existing behavior and/or structure.

ADULTERANTS: Chemicals or substances that by law do not belong in a food, plant, animal, or pesticide formulation. Adulterated products are subject to control by the Food and Drug Administration.

AD VALORUM TAX: Literally, a "value-added" tax. On forest lands, the trees as well as the land itself have value and consequently are taxable. Since the value is in the timber, and presumably this grows incrementally every year, the tax load grows with the timber.

ADVANCED WASTE TREATMENT: Waste water treatment beyond the secondary or biological stage that includes removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids. Advanced waste treatment, known as tertiary treatment is the "polishing stage" of waste water treatment and produces a high quality of effluent.

AEC (Atomic Energy Commission): A five member commission established after World War II to supervise and promote uses of nuclear energy.

AERATION: The process of being supplied or impregnated with air. Aeration is used in waste water treatment to foster biological and chemical purification.

AEROBIC: Refers to life or processes that can occur only in the presence of oxygen.

AGGREGATION AND DISAGGREGATION: Literally, the degree of clustering of objects. In systems modeling, the degree to which variables are lumped together. A highly aggregated model is one that is simplified by lumping compartments and reducing the number of flows needed to interconnect them.

AGRICULTURAL POLLUTION: The liquid and solid wastes from all types of farming, including runoff from pesticides, fertilizers, and feedlots; erosion and dust from plowing; animal manure and carcasses; and crop residues and debris.

AIR POLLUTION: The presence of contaminants in the air in concentrations that prevent the normal dispersive ability of the air (and that interfere directly or indirectly with the health, safety, or comfort of people, or with the full use and enjoyment of their property).

AIR QUALITY CONTROL REGION: An area designated by the Federal Government where two or more communities--either in the same or different states--share a common air pollution problem.

AIR QUALITY STANDARD: Prescribed level of a pollutant in the outside air that should not be exceeded during a specified time in a specified geographical area.

ALLUVIAL: Soil or other deposits bearing moist, sedimentary matter that is found frequently at the base of slopes, in flood plains, and in estuary areas.

AMBIENT QUALITY STANDARD: Maximum level of a specific pollutant allowed in the air, water, soil, or food. May vary from region to region depending on conditions. (See also EMMISSION STANDARD.)

ANAEROBIC: Refers to life or processes that occur in the absence of oxygen.

ANALOGY: A comparison of arrangements, either biological or urban, which are similar in function but dissimilar in structure and origin.

ANALYSIS: The careful dubdividing of a system into its components or subsystems, and determination of how each of these components works.

ANTHRACITE: A hard, black, lustrous coal that burns efficiently and is therefore valued for its heating quality.

ANTICIPATORY PLANNING: A systemic approach that predicts which elements and networks in a system will be affected by any particular design decision or policy formation. Also, the process of planning on the basis of expected short-term (5-20 years) and long-term (25-50 or 100 years) conditions, problems, and results.

ANTI-DEGRADATION CLAUSE: A provision in air quality and water quality laws that prohibits further deterioration of air or water quality.

APPROPRIATE TECHNOLOGY: A resource utilization strategy which supports the notion that our tools and techniques must be appropriate to our lifestyle needs and dreams, as well as to our available resources.

AQUACULTURE: Deliberate growing and harvesting of fish in land-based ponds; frequent usage includes mariculture.

AQUIFER: Underground layer of soil or rock that absorbs and conducts water.

ATMOSPHERE: The air; the layer of gases surrounding the earth.

ATTITUDE: A person's conceptual and emotional receptiveness to certain goals or ideals. The posture individuals hold or society produces in working toward commonly valued ends.

AUTOTROPH: Self-nourishing organism capable of constructing organic matter from inorganic substances.

BASE-LINE: The historical behavior or pattern exhibited by a variable to be forecast.

BEHAVIORAL MODEL: A set of resources and methods designed to facilitate the learning of knowledge and skills.

BENEFIT-COST ANALYSIS: Method of assessing the total positive gain to be derived from introducing a change to a system or subsystem versus the total amount of work required to produce the change and the total negative effect of this change. See also COST-BENEFIT ANALYSIS.

BENEFIT-COST RATIO: An economic summary in which the monetary benefits and monetary costs are summarized and compared.

BIOCHEMICAL OXYGEN DEMAND (BOD): A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. Large amounts of organic waste use up large amounts of dissolved oxygen; thus the greater the degree of pollution, the greater the BOD.

BIODEGRADABLE: Having the potential of being broken down into small molecules by the action of living microorganisms, including bacteria and fungi.

BIOLOGICAL CONTROL: A method of controlling pests by means of introduced or naturally occurring predatory organisms, sterilization, or the use of innibiting hormones, etc., rather than by mechanical or chemical means. Also called "integrated pest management."

BIOLOGY: The study of all living things and their interdependencies.

BIOMASS: The total mass (or weight) of all organisms in a habitat or area.

BIOME: A large geographic area that has the same general type of climate, plant, and animal life.

BIOSPHERE: The section of the earth's crust and atmosphere that supports life.

BOD: See BIOCHEMICAL OXYGEN DEMAND.

B.O.E.: Barrel of oil equivalent; a unit of energy equivalent to the energy in a barrel of crude oil, or 5,800,000 BTU's.

BOUNDARY: A line or area that determines inclusion in and exclusion from a system - includes temporal, spatial, actual, humanocentric, and other distinguishing barriers.

BREEDER REACTOR: Nuclear reactor producing more fissionable material than it consumes.

BRITISH THERMAL UNIT (BTU): The quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit, at or near 39.3° F.

BYPRODUCT: An unintended or undesired system output. What is a product and what is a byproduct depends, of course, on the identity and motives of the entity making the differentiation.

CALORIE: The amount of heat required to raise the temperature of one kilogram of water one degree Centigrade.

CARNIVORE: Any organism that feeds primarily on flesh. Most carnivores are animals. However, insect-eating plants are sometimes put into this category under the specific title of insectivores.

CARRYING CAPACITY: Amount of animal life, human life, or industry that can be supported by a given land mass or area indefinitely on available resources.

CARRYING CAPACITY DETERMINANT: A factor or factors in an environment that alter the carrying capacity, either increasing or decreasing it.

CELSIUS: A metric temperature scale on which the freezing point of water is 0 degrees and the boiling point of water is 100 degrees.

CENTIGRADE: A temperature scale in which the temperature of melting ice is set at 0°, the temperature of boiling water at 100°. One degree Centigrade is 9/5 of a degree Fahrenheit. The Centigrade scale is sometimes known as the Celsius scale.

CHILLING EFFECT: The lowering of the earth's temperature due to the increase of atmospheric particulates that inhibit penetration of the sun's energy.

CHLORINATED HYDROCARBONS: A class of generally long-lasting, broad-spectrum insecticides of which the best known is DDT; first used for insect control during World War II. Other similar compounds include aldrin, dieldrin, heptachlor, chlordane, lindane, endrin, mirex, benzene hexachloride (BHC), and toxaphene. The qualities of persistence and effectiveness against a wide variety of insect pests were long regarded as highly desirable in agriculture, public health, and home uses. Later research has revealed that these same qualities may represent a potential hazard through accumulation in the food chain and persistence in the environment.

CITY: The totality of natural, social, and artificial components aggregated in populous places, including a highly organized culture that includes various skills, but usually lacks self-sufficiency in the production of energy (including food).

CLIMATE-SPECIFIC NEEDS: Needs that are significantly determined by climatic conditions.

CLIMAX COMMUNITY: The final stage in ecological succession; a biotic community with the highest degree of complexity available under prevailing conditions, and with the capacity to reproduce itself.

CLOSED SYSTEM: A system that is totally isolated from its environment, receiving nothing and yielding nothing. A closed system is only a theoretical construct.

COAL: A solid, combustible, organic material formed by the decomposition of plant material without free access to air. It is about 75 percent carbon.

COAL EQUIVALENTS: In one type of systems analysis called "energetics," all forms of energy are expressed in coal equivalents, which are quantities of coal that have an equal ability to do work, resulting in a common energy unit for comparison.

COAL GASIFICATION: The conversion of coal to a gas suitable for use as a fuel.

COEVOLUTION: A special case of evolution in which two or more species develop interdependencies. Examples include various forms of symbiosis and stable predator-prey relationships.

COGENERATION: The utilization of low-quality energy discarded from one process operating on high quality energy to power another process requiring a lower-quality energy.

COGNITIVE MAP: An individual's internal representation of his/her environment, which provides a way of visualizing the physical space in which he/she lives.

COMMONS: Natural resources, especially land, reserved for the common use. Many experts in environmental law also treat rivers, lakes, oceans and atmosphere as commons, and believe that appropriation of the commons for private use is illegitimate.

COMMUNITY: Group of populations occupying a given locality. In human populations, a "sense of community" reflects the welcome interdependence of the population's members.

COMPETENCY BASED/PERFORMANCE BASED TEACHER EDUCATION: Teacher education programs that specify precisely the learning outcomes that are to emerge and the indicators acceptable as evidence of the realization of those outcomes. In both, the emphasis is on the demonstration of competencies or necessary performances. A teacher education model can be content or clinical as well as competency or performance based.

COMPETITIVE EXCLUSION PRINCIPLE: The principle that if two populations compete for some resource that is necessary for the survival of each and is in short supply, one of the populations will be eliminated.

COMPOSTING: A controlled process of degrading organic matter by microorganisms. (1) mechanical - a method in which the compost is continuously and mechanically mixed and aerated. (2) ventilated cell - compost is mixed and aerated by being dropped through a vertical series of ventilated cells. (3) windrow - an open-air method in which compostable material is placed in windrows, piles, or ventilated bins or pits, and is occasionally turned or mixed. The process may be anaerobic or aerobic.

COMPREHENSIVE PLANNING: Planning process that attempts to incorporate whole system costs, benefits, and concerns, not merely those most directly relevant to the endeavor under consideration.

CONDUCTION: The process by which energy is transferred directly from molecule to molecule. Condution is the way in which electricity travels through a wire or heat moves from a warm body to a cool one when the two bodies are placed in contact.

CONSCIOUSNESS: The reflective awareness of an individual within a social and natural world. This includes a refined sense of self, responsibility for and awareness of personal actions, an understanding about the world and its meaning, as well as an appreciation for questions or purpose.

CONSERVATION: Preserving, guarding, or protecting natural resources for the purpose of maintaining them for enjoyment and use of present and future generations.

CONSERVE: To manage or use wisely.

CONSUMER: Organism, human being, or industry that maintains itself by transforming a high-quality energy source.

CONTEXTUAL MAP: A technique that presents the abstract terms of a conceptual model in observable form, such as a graphic rendering.

CONTOUR STRIP MINING: Surface mining by cutting out a series of contour bands. Used on hilly or mountainous terrain; the most destructive form of strip mining.

CONVERSION LOSSES: The energy lost as low-grade waste heat associated with the work done in converting the energy in a fuel source to higher quality energy.

CONVERSION PROCESS: A process by which energy is converted from one form to another, such as radiant energy to heat or electric energy.

COOPERATION: A type of interaction between two species populations in which each population benefits; the interaction is optional for both species.

COSMOLOGY: The whole of creation from the tiniest atoms (in Greek thought) to the most distant galaxies in the universe. The study of the complete known "reality" of a cultural group.

COST-BENEFIT ANALYSIS: Technique of evaluating alternative proposals by comparing present value of all expected benefits with all expected costs.

COUPLING: Implies a causal relationship between or among parts of a system as opposed to linking, which implies temporal coincidence.

CROSS IMPACT ANALYSIS: A forecasting technique that emphasizes the higher-order effects of primary impacts resulting from events or trends.

CULTURAL EVOLUTION: The transmission with modification of nongenetic information; change in a culture over time.

CULTURE: Ways of life, language, social interaction, government, religion, etc., of a group of people.

CULTURE-SPECIFIC NEEDS: Needs that are closely linked with an individual's understanding of his/her cultural environment--traditions, values, trends, etc.

CURRICULUM: All experiences provided the learner by a school. Curricula have certain elements: statement of philosophy and rationale, statement of aims and specific objectives, selection and organization of content, identification of patterns of teaching, and an evaluation program.

CURRICULUM DEVELOPMENT: The generation of those procedures, hardware, materials, organizational framework, and content that have a high probability of success in bringing about a particular outcome or in performing the objective of designing an educational model.

CURVE FITTING: A general name for various mathematical methods of finding an equation to match an observed trend line.

CYBERNETICS: A science that treats the principles of control and communication as applicable to operation of complex machines and to functions of organisms. Cybernetics is the study of methods of feedback control.

CYBERNETIC SYSTEM: A self-regulating system in which control is maintained by information feedback, allowing the system to accommodate to new conditions.

CYCLE: A series of changes that lead back to the starting point. For example, cycles of elements during which elements enter into different compounds but are not lost as they go through the cycle again and again.

DATA BASE: The collection of historical data about a variable on which a forecast of that variable is based.

DECAY: Deterioration or depletion of the components of a system.

DECOMPOSABLE: Some systems may be broken down into constituent parts; they have biodegradable qualities. Others, however, are non-decomposable, e.g., a transistor.

DECOMPOSER: Those organisms that transform dead organic matter into raw materials that can be used again by the producer level of a food series; the final consumer in any food chain.

DECOMPOSITION: Reduction of the net energy level, structure, and change in chemical composition of organic matter because of the actions of aerobic or anaerobic microorganisms.

DEGREE DAY: A term used to determine a heat requirement for a specified period of time.

DELIVERY SYSTEM: The stages by which a resource is delivered for use by the consumer, e.g., exploration, extraction, transport, processing, conversion, and distribution.

DELPHI TECHNIQUE: A forecasting method based on the collection and collation of intuitive forecasts from several experts in a field relevant to the forecast.

DEMOGRAPHIC TRANSITION: The human population phenomenon in which birth rates decline following a period of industrialization and economic development.

DEPLETION ALLOWANCE: A tax allowance extended to the owner of exhaustible resources based on an estimate of the permanent reduction in value caused by the removal of the resource.

DEPLETION CURVE: Plot of the supply and production rate of a non-renewable resource as a function of time; used to predict when the supply might run out or become scarce.

DESIRES: Inputs, the presence of which would enhance the performance of a system, but the absence of which would not seriously impair its well-being.

DESTABILIZATION: The process of breaking down a stable or steady condition, often leading to wild fluctuations or drastic changes.

DIFFERENTIATION: Distinctiveness or distinguishability of the components of a system. Tendency of open systems is toward differentiation and elaboration.

DIRECT ENERGY COSTS: In net energy analysis, the energy consumed in the actual operations of processes in an energy delivery system.

DISCARDED ENERGY: Low-quality energy released to the environment during any physical process because it contains no ability to do useful work. (Same as "waste heat.")

DISSOLVED OXYGEN (DO): The oxygen dissolved in water or sewage. Adequately dissolved oxygen is necessary for the life of fish and other aquatic organisms and for the prevention of offensive odors. Low dissolved oxygen concentrations generally are due to discharge of excessive organic solids having high BOD, the result of inadequate waste treatment.

DISTRIBUTION: The act or process of distributing electrical energy from convenient points on the transmission or bulk power system to the consumers.

DIVERSITY: Complexity or variety. In biology, an ecosystem with many organisms of many kinds with many interrelationships among them is more diverse than one with only a few organisms and few interrelationships.

DRAWDOWN: The distance that the water surface of a reservoir is lowered from a given elevation as the result of the withdrawal of water. Drawdown may refer to the maximum drawdown for power operation, from normal full pool to minimum power pool. Sometimes drawdown is also expressed in terms of acre-feet storage withdrawn.

DRIVING FUNCTIONS: Related to the development of urban places; represents potential energy forces acting as catalysts for change, going through the (city) system unaltered as they provide energy for growth.

DYNAMIC EQUILIBRIUM: A system is in dynamic equilibrium when its input and output are simultaneously of equal quantity. An example of that with respect to population is when the birthrate and the deathrate balance each other. Similarly, a pollution problem is caused when the input of wastes exceeds the ability to dispose of them at the same rate. This theme is important if environmental problems are to be dealt with coherently. In a natural system, that dynamic equilibrium usually exists through the birth-life-death cycle. People, however, have neglected to understand and apply the mechanisms necessary for dynamic equilibrium--not only in relation to the environment, but also in relation to social and cultural systems.

EARTH DAY: An annual observance begun in 1970, whose purpose is to heighten environmental awareness and problem-solving among the general public.

ECOLOGICAL: Pertaining to a living environment.

ECOLOGICAL DETERMINISM: A planning scheme in which the underlying principle is that ecological systems evolve from physical constraints to ecosystems.

ECOLOGICAL ENGINEERING: Planning, designing, constructing, and managing ecosystems based on biological and ecological knowledge; it is hoped that its purpose is maintaining the stability necessary for continued well-being of the ecosystem's inhabitants, including human beings.

ECOLOGICAL IMPACT: The total effect of an environmental change, either natural or man-made, on the ecology of the area.

ECOLOGICAL STABILITY: An equilibrium reached by maintaining a political, biological, and physical balance between people and their environment that can be sustained over a long period of time.

ECOLOGICAL SUCCESSION: Change in the structure and function of an ecosystem; replacement of one kind of community of organisms with a different community of organisms over a period of time. There are two types: primary succession and secondary succession.

ECOLOGY: See BIOSPHERE.

ECOSYSTEM: Or "ecological system" is a self-regulating unit including all of the organisms in a given area interacting with the physical environment so that the flow of energy leads to a clearly defined structure, diversity, material cycle, and rate of change.

ECOTONE: The transition zone between two ecological communities. In the ecotone, the conditions for each of the adjacent communities become more adverse and there is often an intermingling of species from both communities. The ecotone may vary in size from very narrow (e.g., the area where water meets land), to as much as one hundred miles between two continental communities.

EFFICIENCY, EFFICIENCY RATIO: The ratio of useful energy produced by a process in an energy delivery system to the energy input to that process.

EFFLUENT: A discharge of a pollutant into the environment, partially or completely treated or in its natural state. Generally used in regard to discharges into waters.

EKISTICS: The science of human settlements. (Ekistical and the other family of derivatives stem from the Greek "oikos" meaning "habitation or being settled.") Ekistics demonstrates the existence of an overall science of urban systems influenced by biological, social, administrative and technical sciences, economics, and the humanities. C.A. Doxiadis is recognized as the primary spokesperson in this developing field.

ELECTRICAL ENERGY: The energy associated with electric charges and their movements. Measured in watt-hours or kilowatt hours. One watt-hour equals 860 calories.

EMBODIED ENERGY: The sum total of all direct and indirect energies used to produce a product; i.e., the energy used to produce it, plus the energy used to produce input materials, plus energy used to produce their inputs, back to a determined cut-off point.

EMISSION: See EFFLUENT. (Generally used in regard to discharges into air.)

EMISSION STANDARD: The maximum amount of a pollutant legally permitted to be discharged from a single source.

EMPLOYMENT IMPACT ASSESSMENT: Assessment process that attempts to determine direct and indirect job creation and loss that could result from a proposed undertaking, considering quantity, quality, and permanence of impacts.

ENDEMIC: Native, indigenous, peculiar to the region. Restricted to and characteristic of a certain area or environment. For example, in disease, characteristic of an area and a possible epidemic threat without the restriction of rarity.

END-USE: The particular work for which delivered energy is finally used.

ENERGETICS: A method of systems analysis based on the energy flow through a particular system. (Developed by Howard T. Odum, et al., 1976.)

ENERGY: The capacity to do work. Energy is a quantity that is conserved, although it may be exchanged among bodies and transformed from one form to another, or interconverted with mass.

ENERGY CONSERVATION LAW: Energy flowing into a system is equal to energy stored in the system plus energy flowing out of it (all measured in heat equivalents).

ENERGY CONSUMPTION (EXTERNAL): Energy used to power machines and to maintain culture.

ENERGY CONSUMPTION (INTERNAL): Energy used to maintain bodily processes.

ENERGY CONVERSION: The transformation of energy from one form to another.

ENERGY COSTS: In net energy analysis, all of the direct and indirect energy consumed in upgrading energy in an energy delivery system.

ENERGY DEGRADATION LAW: Whether stored or being used, concentrations of energy spontaneously disperse, losing their potential for doing work.

ENERGY DEGRADING: The loss of quality in energy used to improve the quality of other energy in an energy delivery system process, or the maintenance of any energy processing system.

ENERGY DELIVERY SYSTEM: A system composed of the steps required to process energy from resource through end-use.

ENERGY DENSITY: Energy per unit of weight contained in a fuel.

ENERGY EFFICIENCY: A basis for measuring energy performance by describing the efficiency of the link between the energy resources or input and the physical production or output of a system. This efficiency can be expressed as a ratio: $\text{efficiency} = \frac{\text{useful work or energy output}}{\text{energy input}}$

ENERGY FEEDBACK: The process of using high quality energy from an energy delivery system to affect some process in that system.

ENERGY FLOW: The transfer of energy from source to sink (dissipation as heat). In ecological systems, organisms act as filters to trap energy and slow down its ultimate loss as heat. See also HEAT SINK.

ENERGY FLOW DIAGRAM: A graphic depiction of the processes and interrelationships of any system possessing resources and utilizing energy. A set of energy symbols has been developed by Howard T. Odum for use in energy diagramming.

ENERGY QUALITY: A measure of the diversity of useful work that can be obtained from an energy source.

ENERGY DELIVERY SYSTEM: The series of processes needed to change raw fuel into useful work.

ENERGY UPGRADING: The process of improving the energy of an energy source through the combined work of an abundant low quality energy source and high quality energy fed back from a later stage in an energy delivery system.

ENERGY YIELD: The total energy obtained from an energy source.

ENERGY YIELD RATIO: The ratio of total energy obtained to the total energy costs of obtaining that energy.

ENTHALPY: The total quantity of energy contained in a body, without regard to its quality.

ENTROPY: The tendency toward maximum disorder and disorganization. Positive entropy may occur in an open system, but is characteristic of a closed system. Negative entropy, the tendency toward increasing order, applies only to an open system.

ENVIRONMENT: The sum of all external conditions and influences affecting the life, development and, ultimately, the survival of an organism; everything that affects a living organism.

ENVIRONMENTAL EDUCATION: A broadly-based effort to increase awareness of the interrelations between human activities and the natural environment. Such education emphasizes all interactions within both the human systems (techno, social, economic, etc.) and natural systems (biology, physical, ecologic, etc.) and between those two principal systems.

ENVIRONMENTAL EDUCATION ACT: Public Law 91-516 and its amendment, PL 93-278, as passed by Congress in 1970 and 1974. This Act is part of the national effort to improve both current and future environmental quality conditions and supports a range of developmental activities as needed to create the resources for informed participation by citizens in environmental planning and decision-making.

ENVIRONMENTAL IMPACT: A term used in the National Environmental Policy Act of 1969 and hence subject to continuing legal interpretations; generally taken to mean a major negative or positive change in the environment, often including the economic environment of human beings.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA): A process, mandated by the National Environmental Policy Act of 1969 (and similar provisions at the state level), to identify and assess possible impact on the environment resulting from projects utilizing federal (or state) funds, or of alternatives to those projects.

ENVIRONMENTAL IMPACT STATEMENT: A document describing the environmental impact of actions that may affect the quality of the human environment. Environmental impact statements are used as tools for decision-making.

EPA (ENVIRONMENTAL PROTECTION AGENCY): A Federal agency created in 1970 to permit coordinated and effective governmental action for protection of the environment by the systematic abatement and control of pollution through the integration of research, monitoring, standard setting, and enforcement activities.

EPISTOMOLOGY: A theory of method and grounds of knowledge, including verification of what we know and the search for final states of knowledge or ultimate truth.

EQUILIBRIUM: A static or dynamic state of balance between opposing forces or actions, such that there is no change in the state of (rest or motion of) the body; the normal oriented state of the animal body in respect to its environment.

EQUITY: Justice according to natural law or right; the notion of equity guarantees individual and community access both to primary resources and to the goods and services produced from them.

ERDA (ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION): A federal agency created in 1975 to develop a national plan for energy research and development that includes the support of technology studies for the recovery and delivery of energy resources and also the improved efficiency of energy use.

ESTUARY: A semi-enclosed coastal body of water that has a free connection with the open sea. Examples are river mouths, coastal bays, tidal marshes, and bodies of water behind barrier beaches.

EUTROPHICATION: The normally slow aging process by which a lake evolves into a bog or marsh and ultimately assumes a completely terrestrial state and disappears. During eutrophication the lake becomes so rich in nutritive compounds, especially nitrogen and phosphorus, that algae and other microscopic plant life become superabundant, thereby "choking" the lake and causing it eventually to dry up.

EVAPOTRANSPIRATION: When plants photosynthesize, they draw water from the ground through their roots and evaporate much of it through their leaves. This is evapotranspiration and not ordinary evaporation (a physical process that does not require plants).

EVOLUTION: The process of change in response to changing environmental conditions. Evolution is usually taken to mean systematic change without return to the original state, whereas the latter is normally treated as disturbance.

EXCLUSION PRINCIPLE: Interactions among parts of higher level systems essentially ignore the forces of bonding and interaction between the parts on lower levels. For example, forces that bind atoms together ignore the forces that bind subatomic particles together.

EXPONENTIAL GROWTH: The geometric or multiplicative growth of a system operating under more or less positive feedback conditions.

EXTERNAL COSTS: When some part of the cost of an economic activity is borne by persons or organizations outside the economic unit or units engaged in that activity, it is known as an external cost. For instance, the cost of air pollution is to a great extent an external cost of automobile manufacture. External costs are also known as "negative externalities" as opposed to "positive externalities," which are external benefits.

EXTRAPOLATION: The assumption that a particular aspect of the present world will have a smooth continuation into the future.

EXTRAPOLATION FORECASTING: Forecasting with the basic assumption that the future is an inevitable result of present trends, with no concern for factors affecting those trends.

FAHRENHEIT: A temperature scale in which the temperature of melting ice is set at 32° and the temperature of boiling water at 212°. One Fahrenheit degree is equal to 5/9 of a Centigrade degree.

FEEDBACK: The return of part of the output of a system into the input for purposes of modification and control of the output. Negative feedback is a situation in which information comes back to the system in such a way as to decrease the deviation of output from a steady state. Positive feedback occurs when signals are fed back over the feedback channel in such a manner that they increase the deviation of the output from a steady state. When negative feedback discontinues, the system begins to terminate. Feedback involves the alteration of what a system produces when a portion of its output returns to influence the system's behavior. Feedback appears to serve a central role in two of the most important characteristics of all systems, especially living systems. It is a basic mechanism for control and growth, and is so integral that sometimes a subsystem evolves to "sense" the nature of the product and cause change.

FEEDBACK LOOP: A mechanism that provides information to the original system or person, often with the purpose of correcting or improving quality of the performance while the system is in operation.

FENG-SHUI: "Wind and Water." The Chinese art of placing and designing cities, residences, and tombs to harmonize with local currents of energies flowing through the environment.

FIRST LAW OF THERMODYNAMICS: Also called the Law of Conservation of Energy. It states: Energy can neither be created nor destroyed.

FISSION: The splitting of an atomic nucleus to release tremendous amounts of energy; in biology, vegetative reproduction of plant or animal cells.

FLEXIBILITY: An "uncommitted potentiality for change." (See Gregory Bateson, Steps to an Ecology of Mind, p. 497.) He maintains that the goal of the "ecological analyst" is to "create flexibility and prevent the civilization from immediately expanding into it."

FLOOD PLAIN: The land contiguous to water that has been inundated by that water when its regular channel capacity is exceeded. Rivers in broad valleys usually have a very wide flood plain.

FOOD CHAIN: A series of organisms dependent on one another for food (more accurately called a food web). Most food chains begin with plants or micro-organisms and end with the largest carnivores.

FORECAST: A conditional statement about a future possibility.

FORECASTING: The act of speculating about the future and making some statement about its likely composition, given certain conditions.

FOSSIL FUEL: Any naturally occurring fuel of an organic nature, such as coal, oil shale, natural gas, or crude oil.

FREE-ENERGY: The energy in a fuel available for work (enthalpy).

FREE MARKET: The ideal market of classical economics. It is characterized by many sellers and many buyers, each having such small influence on the price and operation of the market that their individual actions do not affect price or market conditions.

FUEL: Any substance that can be burned to produce heat; sometimes includes materials that can be fissioned in a chain reaction to produce heat.

FUSION: The formation of a heavier nucleus from two lighter ones, such as hydrogen isotopes, with an attendant release of energy. The mass of the new, heavier nucleus is less than the combined masses of the original nuclei; the lost mass appears as energy.

FUTURES RESEARCH: A field of research that focuses on the possible future states of the world, the means of knowing those possible states, and the preparation necessary to deal with those states.

FUTURES THINKING: The general activity of studying all possible aspects of the future to aid in present decision-making.

FUTURISTICS: Same as FUTURES RESEARCH.

FUZZY SET SYSTEM: A system that is evidently a system, but with indistinct boundaries. The boundaries of a pond ecosystem are easy to specify; those of a worldview nearly impossible.

GAS, NATURAL: A naturally occurring mixture of hydrocarbon. Gases found in porous geologic formations beneath the earth's surface, often in association with petroleum. The principal constituent is methane.

GASOLINE: A refined petroleum distillate composed primarily of light hydrocarbons. Since light hydrocarbons are a relatively small percentage of crude petroleum, most gasoline is produced by refining ("cracking") crude oil.

GENERAL SYSTEMS THEORY: A logico-mathematical field, the subject matter of which is the formulation and derivation of those principles that hold for systems in general.

GENIUS LOCI: The inherent qualities of a landscape site, both physiological and psychological.

GEOTHERMAL ENERGY: The heat energy available in the rocks; hot water and steam in the earth's subsurface.

GREEN BELTS: Certain areas restricted from use for roads, buildings, and houses; they often serve as separating buffers between pollution sources and concentrations of population. Green belts are often used for agricultural or recreational purposes.

GREENHOUSE EFFECT: The heating effect of the atmosphere upon the earth. Light waves from the sun pass through the air and are absorbed by the earth. The earth then reradiates this energy as heat waves that are absorbed by the air, specifically by carbon dioxide. The air thus behaves like glass in a greenhouse, allowing the passage of light but not of heat. Thus, many scientists theorize that an increase in the atmospheric concentration of CO_2 can eventually cause an increase in the earth's surface temperature.

GROSS ENERGY: Same as ENERGY YIELD.

GROSS NATIONAL PRODUCT (GNP): The total market value of the goods and services produced by the nation before the deduction of depreciation charges and other allowanced for capital consumption; a widely used measure of economic activity.

GROUNDWATER: The supply of water under the earth's surface in an aquifer or soil that forms a natural reservoir.

GROUNDWATER RUNOFF: Groundwater that is discharged into a stream channel as spring or seepage water.

GROUP CONSENSUS: Forecasting based on the collective intuitive forecasts of several experts.

HABITAT: The sum total of environmental conditions of a specific place that is occupied by an organism, a population, or a community.

HEAT: Energy in the form of motion of molecules; a form into which all other types of energy may be converted.

HEAT CONTENT: Same as ENTHALPY.

HEAT ISLAND EFFECT: An air circulation problem peculiar to cities. Tall buildings, heat from pavement and concentrations of pollutants create a haze dome that prevents rising hot air from being cooled at its normal rate. A self-contained circulation system that can be broken by relatively strong winds is put in motion. If such winds are absent, the heat island can trap high concentrations of pollutants, presenting a serious health problem.

HEAT PUMP: A device that transfers heat from a cooler region to a warmer one by the expenditure of mechanical or electric energy. Heat pumps work on the same general principle as refrigerators and air-conditioners, but are reversible and can pump outside heat in to warm or inside heat out to cool.

HEAT SINK: The medium or location to which waste heat is discharged and where, hopefully, it is dissipated without producing undesirable environmental effects.

HERBIVORE: An organism or animal that feeds on vegetation.

HETEROTROPH: Organism that cannot produce its own food but lives on other organisms, including autotrophs. All animals and some plants are heterotrophs.

"HIDDEN AGENDA": The movement of societies toward the realization of ideals depends upon perception, decision-making, and action. Further, selection for certain sanctioned behavior is made via complex economic and other normative means. The hidden agenda is the uncertain "program" behind which society rallies its energies.

HIERARCHY: An arrangement of (persons or) things in successive orders or classes, each of which is subject to or dependent on the one above it.

HIGH-GRADE ENERGY: Energy with a high quality, useful for many different kinds of work.

HISTORACISM: The order-creating principles of the mind vary with the succession of epochs and cultures. Historacism underpins the "truth" and essence of each historical era by studying ages and their historical actors in light of their unique worldviews.

HOLISM: The movement in many fields today to consider totalities in finding solutions rather than concentrating on a particular aspect. A movement away from specialization and fragmentation.

HOLISTIC: That which lends itself to or embodies holism; i.e., that which merges many disciplines or fields of knowledge.

HOLISTIC LIFESTYLE ASSESSMENT: The process of evaluating, by means of a variety of integrative tools, the whole system, long term costs/benefits of individual or collective decisions. Energetic analysis and environmental impact assessment are examples of two important tools that can be used in that process.

HOMEOSTASIS: Any process--physical, chemical, physiological, behavioral, cultural, or genetic--by which a system tends to keep crucial variables within their ranges of viability, or tends to return them to such ranges should they depart from them.

HYDROELECTRIC PLANT: An electric power plant in which energy of falling water is converted into electricity by turning a turbine generator.

HYDROLOGY: The science dealing with the properties, distribution, and circulation of water and snow.

HYDROPONICS: The art and science of growing plants in a nutrient solution instead of in soil. Already in commercial use for some of the more profitable and easily managed types of cash crops (e.g., tomatoes), hydroponics is not likely to have much effect on the world food situation for the time being because it requires a high level of investment and technological sophistication.

HYDROSPHERE: The water "world," including atmospheric water vapor, ground water, and oceans, lakes, streams.

IDEALISM: A philosophical school whose beliefs are based on the idea that mind and spiritual values are fundamental in the world as a whole.

IDEOLOGY: A self-contained and fully insulated package of beliefs based on the idea that mind and spiritual values are fundamental in the world as a whole.

INDICATOR: Variable that performs the function of a diagnostic tool, pointing to a condition that is defined as being related to a concept or problem area.

INDICATOR SPECIES: Species whose presence, absence distribution, or abundance measures the effect of some influence on the system (e.g., pollution).

INDIRECT ENERGY COSTS: The energy consumed to produce goods or to run processes that support the operations of an energy delivery system.

INFORMATION FLOW: That throughput of a system which is used to monitor the system's behavior.

INFRARED: Rays just beyond the visible red of the electromagnetic spectrum; heat waves, that is, those with wavelengths longer than visible light and shorter than radio waves.

INPUT: Matter, energy, or information that a system or subsystem takes into itself for processing, maintenance, or expulsion.

INTEGRATED PEST CONTROL: A system of managing pests by using biological, cultural, and chemical means.

INTERDEPENDENCE: Every part of a system is so related to every other part that a change in a particular part causes a change in all the other parts and in the total system; or a change or changes in one or more of the parts in a system noticeably affect the system as a whole or one or more of its parts in complex ways.

INTERACTION: Mutually effective action involving two or more systems of the same or different orders.

INTERMEDIATE TECHNOLOGY: A resource utilization strategy that stresses "technology with a human face" and seeks to make technological self-reliance possible by promoting small-scale production of goods and services.

INTUITIVE FORECASTING: The non-rigorous act of forecasting the future on the basis of one's educated or common-sense knowledge of the world and subjective expectations of the world's development.

INVERSION: In meteorology, the phenomenon that occurs when the layer of air nearest the earth's surface is cooler than the layer above, so that the pollutants in the lower layer are trapped there. Topographical features such as basins and river valleys intensify this phenomenon, which is also known as "temperature inversion."

ISOMORPHISM: A sense of "oneness with" or identification with other people or "things," which one can assume to be similar in form, structure, or spirit--thus allowing for a sharing experience.

KCAL (kilocalorie, the so-called large calorie): The amount of heat required to raise one kilogram of water one degree centigrade; the term is used mainly in physics.

KILOWATT-HOUR (kWh): 1,000 watt-hours. A unit of electrical energy equal to the energy delivered by the flow of one kilowatt of electrical power for one hour. (A 100-watt bulb burning for 10 hours will consume one kilowatt-hour of energy, or enough to lift a 150-pound person 20,000 feet into the air). One barrel of oil equals 500 kWh.

LAND POLLUTION: Contamination of the life support system of land, as by solid wastes, excessive populations, removal of land from productivity, penetration of toxic substances.

LAND USE PLANNING: Planning for the long-term management and maintenance of land resources for the mutual benefit of the natural environment and the human settlements embedded within it. Freedom to vary land use planning is or should be heavily constrained by the carrying capacity (see definition) of the land area in question.

LEVEL AND GAP: Entities in natural and man-made systems tend to cluster in groupings that we call a level; between that and the next grouping in the system, there is a gap. The difference between a natural and a man-made system is that in the former the gap is narrow, gradation is subtle; whereas in a man-made system, the gap may be great, as, for example, in a small organization, the difference between the "boss" and the members of the staff.

LIFE CYCLE: The phases, changes, or stages an organism passes through during its lifetime.

LIFE CYCLE COSTING: A measure of the total anticipated costs of owning and operating an appliance or other device, including initial capital cost, energy and other operating costs, and maintenance.

LIFE CYCLE COSTS: The cost of an item year by year, including initial purchase price as well as cost of operation, maintenance, etc., over the life of the item.

LIFESTYLE: An individual's typical way of life; an aggregate of consumption, activity, and behavior patterns that reflect the worldview, as well as cultural and climatic contexts, of an individual.

LIMITING FACTOR: A factor that controls species location and population size, such as shortage of water, food, etc.

LIMITS OF TOLERANCE: The range of boundary variations (input or output) that a system can accept without adverse and/or irreversible changes in system structure and/or function.

LINKAGES: The qualities and processes that give unity to a subsystem and integrate subsystems into a "one." They are ultimately the "input" and "output" of a system.

L.N.G.: Liquified natural gas.

LOW-GRADE ENERGY: Energy with a low quality, from which little or no work can be obtained.

L.P.G.: Liquified petroleum gas. Hydrocarbon fractions lighter than gasoline (such as butane and propane), which are kept under pressure in a liquid state and marked for various industrial and domestic gas uses.

MALTHUSIAN THEORY OF POPULATION: Theory (first published by Thomas Malthus) that population tends to increase as a geometric progression (1, 2, 4, 8, 16, 32, etc.), while food tends to increase as an arithmetic progression (1, 2, 3, 4, 5, etc.). The conclusion is that human beings are therefore destined to misery and poverty unless population growth is controlled.

MARICULTURE: Deliberate cultivation of fish and shellfish in estuarine and costal areas.

MARKET ECONOMY: Sometimes called the free-market economy or just the supply-demand mechanism. In free-market economies, supply and demand are controlled automatically through price changes, with no need for central decision-making.

MARSH: A low-lying tract of soft, wet land that provides an important ecosystem for a variety of plant and animal life.

MAXIMUM-POWER PRINCIPLE: Systems with more energy flow displace those with less flow; or, systems that capture more energy (or at a faster rate) displace (survive over) systems that capture less energy (or at a slower rate).

MEASURE OF ECONOMIC WELFARE (MEW): A proposed replacement for Gross National Product as a measure of social performance, the MEW corrects for urban disamenities; reclassifies education and health expenditures as capital investments, thereby recognizing their value to society, and inputes value to leisure and non-market work and voluntary services.

MEGALOPOLIS: Very large continuous urban area or city belt formed by the joining or near joining of a number of cities.

METASTABILITY: When a system appears to be undergoing no recognizable change, it is in a metastable state. Change is always involved, and what actually occurs is a unidirectional process of very slow change, which results in great insensitivity to perturbation. Because unidirectional change is unusual in natural systems, the term is generally applied to phenomena in man-made physical systems. For example: Concrete appears to be unchanging, but actually it goes through a continual curing process that is irreversible in the entropic sense.

METABOLISM: All of the chemical reactions taking place within an organism.

MICROCOSM: In one sense, a working model of a system. A microcosm usually is a simplified version of a more complex system constructed from a few of the elements of the system.

MONOCULTURE FORESTRY: A forest management practice whereby production of each economically valuable tree genus is limited to a single, genetically superior species, subspecies, or genotype that has been bred to exhibit both a rapid and highly predictable growth rate and physiological characteristics of high economic value.

MORPHOLOGICAL ANALYSIS: A forecasting method that utilizes network structures for organizing all possible events into all possible paths from the present state to a particular future state.

MORPHOLOGICAL MATRIX: A multi-dimensional device for indexing and classifying the information, effects, or solutions within a defined domain. For example, the Periodic Table, which made it possible to predict the nature of undiscovered elements.

MORPHOLOGY: A method for exploring all possibilities within an explicitly stated situation, based on the work of F. Zwicky. Not a science, but an elaborate system of organized "common sense," which excludes external values until _after_ all possible solutions have been established.

MULTIPLE USE: Designing a program or directing its execution such that several purposes can be carried out simultaneously. The opposite is exclusive use. The U.S. Forest Service and water development projects generally emphasize the multiple use concept.

MYTH: A usually traditional story of ostensibly historical events that serves to unfold part of the worldview of a people, or to explain a practice, belief, or natural phenomenon.

NATURAL GAS: A naturally occurring mixture of hydrocarbons found in porous geologic formations under the earth's surface, often in association with petroleum. Natural gas is almost pure methane, CH_4, but also contains small amounts of various more complex hydrocarbons.

NATURALISM: The philosophical school whose beliefs are based on the premise that the natural world known and experienced scientifically (via observation) is all that exists. Such a doctrine denies that anything in "reality" has supernatural significance.

MINE-MOUTH PLANT: A steam-electric plant or coal gasification plant built close to a coal mine and usually associated with delivery of output via transmission lines or pipelines over long distances, as contrasted with plants located nearer load centers and at some distance from sources of fuel supply.

MODEL: Although there is no unified definition of this term, a model is generally a description of a set of unknown or unfamiliar existing or future entities and their relationships in terms of familiar theories or laws.

MODELING: A forecasting method that utilizes some rigorous framework such as a chart or computer program to keep track of complex interactions observed in the world.

MONITORING: Periodic or continuous determination of the amount of pollutants or radioactive contamination present in the environment.

MONOCULTURE AGRICULTURE: The farming practice that concentrates on the production of a single species that has proven superior in yield and insect and disease resistance, but usually requires the support of considerable technology.

NATURAL RESOURCES: The essential resources supplied by nature, such as water, land, minerals, and fuel sources.

NATURAL SYSTEMS: Usually refers to the various systems of the natural environment, which have both abiotic and biotic forms; some components of natural systems are weather, water, landforms, soils, and biota.

NEEDS: Inputs required by a system without which its functioning or well-being would be seriously impaired.

NEGATIVE FEEDBACK: Feedback that is used to correct the system in such a way that the system returns the output to the the predetermined condition or set point.

NESTED SYSTEMS: The situation in which one system is contained within another system.

NET ENERGY: High-quality energy produced in a process in excess of high-quality energy used in the process. The energy remaining to do work from the total energy producible from the energy resource minus (1) the energy losses due to the processes of extraction, conversion, and delivery or (2) the total amount of energy required to produce the energy from its original form.

NET ENERGY ANALYSIS: A method for determining and quantifying the relationships between energy used in the process and energy produced in the process. The method of determining the net energy available or remaining from an energy resource after subtracting out the total amount of energy required to produce the energy.

NET ENERGY PROFIT: The energy obtained from an energy delivery system or other system minus all of the energy costs of powering that system.

NET NATIONAL WELFARE (NNW): A proposed broadening of GNP as a measure of national performance by incorporating social as well as economic factors. (See MEW.)

NOISE POLLUTION: A sound volume of unpleasant or injurious intensity.

NONRENEWABLE RESOURCE: Resource such as minerals, coal, or oil, that exists in a finite quantity in the earth.

NORMATIVE FORECASTING: Forecasting with the assumption that a particular future state (the goal or norm) is desirable; planning activities leading to the attainment of that goal.

NORMATIVE STANDARDS: Quantitative standards requiring statistics and often resulting in regulations, such as building standards or zoning boundaries.

NUCLEAR ENERGY: Energy produced largely in the form of heat during nuclear reactions, which, with conventional generating equipment, can be transformed into electrical energy.

NUCLEAR FISSION: The splitting of large atomic nuclei into two or more new nuclear species, with the release of large amounts of energy.

NUCLEAR FUSION: The process by which small atomic nuclei join together, with the release of large amounts of energy.

NUCLEAR POWER: Electrical power produced from a power plant by converting the energy obtained from nuclear reaction.

NUCLEAR POWER PLANT: Any device, machine, or assembly that converts nuclear energy into some form of useful power, such as mechanical or electrical power.

NUCLEAR REACTOR: A device in which a fission chain reaction can be initiated, maintained, and controlled. Its essential component is a core with fissionable fuel. It usually has a moderator, reflector, shielding, coolant and control mechanisms. It is the basic machine of nuclear power.

NUTRIENT: A substance necessary for the normal growth and development of an organism.

OIL SHALE: A sedimentary rock containing solid organic matter from which oil can be obtained when the rock is heated to a high temperature.

OMNIVORE: An animal whose food consists of both plant and animal matter.

ONTOLOGY: The study of the origin and ends of being/existence in human relations and the world.

OPEN SPACE: Another user-defined term referring to an undeveloped or lightly developed area. Most often used for wilderness and parks.

OPEN SYSTEM: System in which energy and matter are exchanged between the system and surroundings. A living organism is an example.

OPTIMIZATION: The process of making behavior of a system or system component as perfect, effective, or functional as possible in relation to particular goals.

OPTIMUM POPULATION: Level of population that allows a high quality of life for everyone.

ORGANIC: Referring to or derived from living organisms. In chemistry, any compound containing carbon.

OUTPUT: Matter, energy, or information that a system or subsystem puts back into the environment. Output includes useful matter, energy, information, "waste."

OVERLOAD: The placing of quantitative demands on the capacities of a system that it cannot handle.

PARADIGM: A kind of construction or model of a theoretical reality which, in a certain epoch of science, has its own self-contained questions, models of inquiry, and verification. Accompanying a paradigm is a worldview and the limits that worldview implies.

PARTICIPATORY PLANNING: Planning process designed to allow for, or encourage, maximum involvement by those who may be affected by the results of the process.

PAYBACK PERIOD: The time required for an energy producing device to produce as much energy as was consumed in building the device.

POLICY: A rule or set of rules to guide the making of individual decisions.

POLLUTION: The accumulation of wastes or byproducts of human activity. Pollution occurs when wastes are discharged in excess of the rate at which they can be degraded, assimilated, or dispersed by natural processes. Although the concept of pollution is generally understood in terms of human processes, there are many examples of "natural" pollution, including pollution from volcanic eruptions and natural oil seeps.

POPULATION: All the organisms of a given kind in an area at a specific time; also may refer to all species in an area.

POPULATION DENSITY: Number of organisms per unit area.

POSITIVE FEEDBACK: Information sent back into a cybernetic system that causes the system to change continuously in the same direction. As a result, the system can go out of control. (See also FEEDBACK.)

POSITIVISM: A refinement of Naturalism originating with Comte which excludes everything not reducible to natural phenomena or properties of knowable objects and things. (The exclusive grounding of "truth" in raw, sensory experience.)

POTENTIAL ENERGY: Energy in an inactive form that is the result of relative position or structure instead of motion, as in a coiled spring or stored chemicals.

POWER: The rate at which work is done or energy expended. It is measured in units of energy per unit of time such as Calories per second, and in units such as watts and horsepower.

POWER DENSITY: The relationship of physical structure to energy flowing through an area divided by the spatial area.

PREDICTION: A statement that the world will be in a certain state at a specified time, regardless of the different possible states conceivable at the present.

PRE-SUPPOSITIONS: The assumptions we make about humans and the world--from which we proceed with theorizing. Pre-suppositions are not testable but are subject to belief, just as mathematics relies upon axioms for its beginning point.

PRIMARY ENERGY RESOURCES: Fuels used specifically to power processes in society.

PRIMARY PRODUCERS: Organisms (green plants or certain bacteria) that produce organic compounds through photosynthesis or chemosynthesis.

PRODUCER: Organism, human being, or industry that generates high-quality energy by transforming and combining low grades of sunlight and other energy sources and raw materials in excess of its own use.

PROJECTION: A statement that the world will be in a certain state if certain conditions prevail.

PROVED RESERVES: The estimated quantity of crude oil, natural gas, natural gas liquids, or sulfur which analysis or geological and engineering data demonstrates with reasonable certainty to be recoverable from known oil or gas fields under existing economic and operating conditions.

PUBLIC UTILITY DISTRICT: A potential subdivision (quasipublic corporation of a state) with territorial boundaries embracing an area wider than a single municipality and frequently covering more than one county, for the purpose of generating, transmitting, and distributing electrical energy.

PUMPED HYDROELECTRIC STORAGE: The only means now available for the large-scale storage of electrical energy. Excess electricity produced during periods of low demand is used to pump water up to a reservoir. When demand is high, the water is released to operate a hydroelectric generator. Pumped energy storage returns only about 66% of the electrical energy put into it, but costs less than an equivalent generating capacity.

QUADRILLION BTU: 10^{15} (thousand million million) BTU's; equal to the heat value of 965 billion cubic feet of gas, 175 million barrels of oil, or 38 million tons of coal.

QUALITY OF LIFE: A relative standard (see "relative standard") of ideal conditions or existence, perceived differently by individuals and groups.

RADIATION: A flow of pure energy or of high energy atomic particles or molecules. The emission of fast atomic particles or rays by the nucleus of an atom. Some elements are naturally radioactive while others become radioactive after bombardment with neutrons or other particles.

RADIOACTIVITY: The spontaneous decomposition of an atom, accompanied by the release of energy.

RATE BASE: The value, specified by a regulatory authority, upon which a utility is permitted to earn a specified rate of return.

REACTOR: A device in which nuclear fission is sustained in a self-supporting chain reaction.

RECYCLE: To reintroduce a substance, element, or artificial materials (especially waste products) into an ecosystem; to reactivate inert materials.

REFORESTATION: The replanting of trees in forests that have been denuded by cutting, fire, disease, insects, or other decimating factors. Also "urban reforestation" - replanting of trees and gardens in a city.

REFUSE RECLAMATION: The collection and process of converting solid waste to saleable products. For example, the composting of organic solid waste yields a saleable soil conditioner.

RELATIVE STANDARDS: Qualitative standards that are dependent on an individual or group perspective of a situation or problem.

RELATIVISM: The condition where all truth, ethics, or moral knowledge are relative in time and place, hence fluid and never absolute. Relativism states that all "objective" knowledge is impossible.

RENEWABLE RESOURCE: A natural resource that is available to humanity at specific rates depending on locale; their availability as an energy resource is also a function of available technology and capital investiment. Sunlight, water, and wind are examples of renewable resources.

RESERVES: The amount of a fuel or other mineral resource known to exist and expected to be recoverable by existing techniques and under existing economic conditions.

RESILIENCE: The ability of a system to return to a stable state after some perturbation.

RESOURCE: The total estimated amount of a mineral, fuel, or energy source, whether or not discovered or currently technologically or economically extractable.

RESOURCE BASE: The entities (human, capital, or natural) available for an activity or enterprise.

RESOURCE DELIVERY SYSTEM: The activities or phases, and their relationships, of moving a resource from its natural site to a point of end use.

RESOURCE RECOVERY: The process of recovering unused and reusable materials or energy, particularly from solid waste.

RESPIRATION: Aerobic oxidation of food or organic substances by organisms, which releases usable energy, carbon dioxide, and water.

RESTRUCTURING: The ability of a system to capture elements or energy flows of other systems to support itself; the transformation of a part of the environment by the system.

RUNOFF: The portion of rainfall, melted snow, or irrigation water that flows across ground surface and eventually is returned to streams. Runoff can pick up pollutants from the air or the land and carry them to the receiving waters.

RUNOFF INDEX: Runoff expressed as percentage.

SCENARIO: An imaginative depiction of a possible course of events; sometimes described in the past tense as history by a fictional character living at some future date.

SCENARIO WRITING: A forecasting method that is a combination of intuitive and mathematical projection, with no rigorous methodological framework.

SECONDARY ENERGY SOURCES: Recycled energy from processes powered by primary energy sources.

SECOND LAW OF THERMODYNAMICS: Law stating that in any spontaneous process there is a net increase in disorder or entropy when both the system and its environment are considered. Can also be expressed as the degradation of energy to less and less useful forms (heat) as it flows through an ecosystem.

SELF-EVIDENTIAL PRESENTATION: A methodology for the presentation of material in which the stages of the process through which information is used to draw conclusions or to make decisions correspond to the stages in the presentation itself.

SHELLBUILDING: Originating with Jaspers, this term refers to the creation of closed, self-validating (ideological) belief systems that tend to be absolutistic (exclusive) in their character.

SIMULATION: Examination of a problem area by using an imitative representation of a real-life situation; a technique used in forecasting with formal models, in which the world is represented by mathematical equations and the future is projected by solving the equations to simulate the activities of the world.

SLUDGE: The construction of solids removed from sewage during waste water treatment. Sludge disposal is handled by incineration, dumping, or burial.

SMOG: Originally, a combination of "fog" and "smoke"; now applied also to the photochemical haze produced by the action of sun and atmosphere on automobile and industrial exhausts.

SOCIAL IMPACT ASSESSMENT (SIA): A broader approach than Environmental Impact Assessment; SIA estimates and appraises the condition of society as it is organized and changed by proposed undertaking, considering what is technologically practical, environmentally appropriate, socially acceptable, economically viable, legally sound, and politically feasible.

SOCIOLOGY OF KNOWLEDGE: The study of the relationship between thought and society, with the assumption that thought is absolutely related to the historical and social context from which it emerges.

SOLAR CELL: A device that converts solar radiation to a current of electricity.

SOLAR COLLECTOR: A device for collecting solar energy and converting it into heat.

SOLAR EQUIVALENTS: In one type of energy analysis, all forms of energy are expressed in solar equivalents--the amount of sunlight having an equivalent ability to do work. Often expressed in terms of the solar constant: 1.36 kw/m^2.

SOLAR POWER: Power produced by using the sun's radiation to directly produce heat or electricity.

SPECIES DIVERSITY: Refers to the number of different species occupying the same area.

STABILITY: The property of a system that enables it to return to an equilibrium or steady state when it is disturbed. In ecosystems, the capacity that allows them to persist.

STATE: (1) The condition of a system at a given moment; or (2) the condition of a system during a given period. The difference concerns the duration of the state.

STEADY STATE: Pattern that is constant; it is based on a balance of inflows and outflows. Example: a river with an unchanging water level.

STEADY-STATE-ECONOMICS: A fairly new branch of economic thinking based on the idea of a stable society operating at a constant resource throughput safely below its natural growth limits.

STEWARDSHIP WORLDVIEW: A worldview that accommodates new values and new concerns regarding human and natural system interactions, taking into account the finite nature of our resources and the principle of equitable access to these resources.

STORAGE: Usually stored potential energy represented as the difference between inflows and outflows during a specific time.

STRESS: Specific series of bodily reactions that an organism undergoes in response to many different stimuli. Broadly, the reactions of any system in response to changing or increasing inputs.

STRIP MINING: A mining technique used when deposits of coal lie relatively near the surface (less than 100 feet). The overburden (the soil and rock above the coal) is stripped away, the coal is removed, and the overburden from a trench is dumped in the previous, and parallel, one. Strip mining is used primarily for coal, but may be used extensively in the mining of oil shale as well.

SUBSIDY: A payment from one unit of a system to another; aid, support.

SUBSYSTEM: A system that can also be considered as a single component part of a larger system.

SUCCESSION: Sequence of stages and changes that occurs in an ecological system as it goes from some starting condition to a steady state.

SUPRASYSTEM: The next highest system in which any living system is a component or subsystem. For example, the suprasystem of a cell or tissue is the organ containing it.

SURPLUS: Energy generated that is beyond the immediate needs of the producing system.

SURVIVING SYSTEMS: Those systems that are most successful in utilizing energy and, thus, survive over other systems.

SUSTAINED YIELD: On the average, an exploited population will produce enough biomass as individuals to recover the losses of exploitation. A population at sustained yield is in steady state with maximized production.

SYMBOL: Something that has come to mean or stand for something else by common agreement or custom.

SYNERGISM: The cooperative action of separate substances so that the total effect is greater than the sum of the effects of the substances acting independently.

SYNTHESIS: The reassembly of a system after the subsystems or components have been analyzed and processed.

SYSTEM: A combination of parts organized into a unified whole, usually processing a flow of energy.

SYSTEM BOUNDARY: An arbitrary limit drawn around a system in order to make the study of that system manageable.

SYSTEMS ANALYSIS: The analysis of any complex phenomenon in terms of the relations between the subsystems that form its constituent parts. The general goal is to predict the behavior of the whole from that of its parts, rather than vice versa.

SYSTEMS APPROACH: A way of thinking about problem solving and model development that involves thinking about a complex series of events or things as a single whole.

SYSTEMS ECOLOGY: That section of ecology that deals with (1) models and (2) entire functional assemblages, usually ecosystems.

TEACHER EDUCATION MODEL: An integrated set of specifications that establish boundaries or parameters for the structure, function, content, and operation of a teacher education program; a framework within which operational programs can be created. Fact, theory, and creative ideas make each model different.

TECHNOLOGY ASSESSMENT: One field of forecasting that emphasizes the impacts of particular technologies on all perceivable aspects of society.

TELEOLOGY: The study of final causes or essences behind events, and of their ultimate purpose. This school of thought maintains that ends are immanent in nature--flowing from being rather than reducible to mere mechanical causation.

THEORY: This term can be used in a large variety of ways. However, it appears to have three basic components: (1) a logical structure that implicitly defines the basic motions of a system; (2) a set of rules that assigns an empirical content to the logical structure by relating it to observation and experimentation; (3) a model of the logical structure that enables one to describe it on more or less familiar conceptual or visualizable materials.

THERMAL EFFICIENCY: The ratio of the electrical power produced by a power plant to the amount of heat produced by the fuel; a measure of the efficiency with which the plant converts thermal to electrical energy.

THERMAL POLLUTION: An increase in the temperature of water resulting from waste heat released by a thermal electric plant to the cooling water when the effects on other uses of the water are detrimental.

THERMAL POWER PLANT: Any electric power plant that operates by generating heat and converting the heat to electricity.

THERMODYNAMICS: The science and study of the relationship between heat and mechanical work.

THERMODYNAMICS, LAWS OF: The first law of thermodynamics states that energy can neither be created nor destroyed. The second law of thermodynamics states that when a free exchange of heat takes place between two bodies, the heat is always transferred from the warmer to the cooler body.

THROUGHPUT: Matter, energy and information that flows through a system or subsystem. Some of this throughput must be used to maintain and control the system.

TIME HORIZON: The time period over which a forecast extends.

TOPOGRAPHY: The configuration of a surface area including its relief, or relative elevations, and the position of its natural and man-made features.

TOPOLOGY: A topographical study of a particular place; the history of a region as indicated by its topography.

TOTAL SYSTEMS APPROACH: A comprehensive view of the outputs of industrial, commercial, residential, and public wastes, as well as their linkages (or feedback loops), including physical and social interrelationships.

TRANSFORMATION, LAW OF: All transformation processes (throughputs) involve the production of an intended output and unintended byproducts.

TRANSGRESSIVE EQUILIBRIUM: Certain entities share a harmonious stability/instability balance that enables them to combine to generate a new level of hierarchy, and thereby to establish a new equilibrium. This accounts for the origins of new systems from subparts.

TREND: A pattern of events; the tendency or direction of movement of some past variable.

TREND EXTRAPOLATION: A forecasting method that is based on the assumption that a trend observed in the past and present will continue smoothly into the future.

TROPHIC LEVEL: A particular position in the food and energy hierarchy that indicates the organism's relationship with its counterparts in any living community.

URBAN ECOLOGY: The study of living things, their relations with each other, and their nonliving environments in cities.

URBANIZATION: The establishment and development of cities.

URBAN REFORESTATION: The replanting of tree crops (food and fiber) in urban areas that have been denuded by cutting, fire, disease, insects, or urban growth.

VALUE ADDED: The difference between the value of a delivered product and the cost of the raw materials, labor, and energy used to produce it.

VALUES: Normative, problems concern the ideals, goals, preferences set forth by a society/or people to move toward desired ends. Values are the crucial linkage between imaginative ideals and a commonly motivated social action.

VARIABLE: A general name given to any changing aspect of the world that we desire to observe, measure, or forecast.

VOLUNTARY SIMPLICITY: A lifestyle that embraces frugality of consumption, a sense of environmental urgency, human-scale working environments, and appropriate technology.

WASTE: (1) In nature, by-products of metabolism or decomposition are readily broken down and recycled unless in excess; for example, urine and feces. (2) In society, material that is thrown away as useless, such as packaging material, broken machines, sewage, garbage, refuse from building construction and destruction, and by-products of industrial processes that are difficult or impossible to recycle.

WASTE HEAT: Low-quality energy discharged from a process in the form of heat because no further useful work can be obtained from it.

WATER POLLUTION: The addition of sewage, industrial and institutional wastes or other harmful or objectionable material to water in concentration or in sufficient quantities to result in measurable degradation of water quality.

WATER QUALITY CRITERIA: The level of pollutants that affect the suitability of water for a given use. Generally, water uses are classified as: public water supply; recreation; propagation of fish and other aquatic life; agricultural; and industrial.

WATERSHED: The entire region or drainage area that contributes to a water supply point.